SCIENCE

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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

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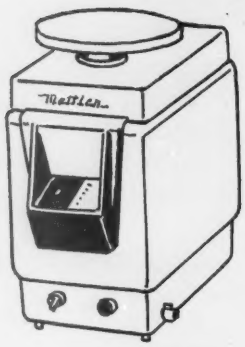

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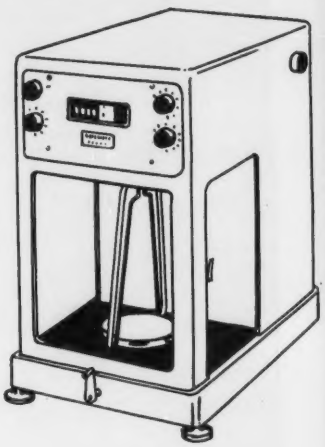

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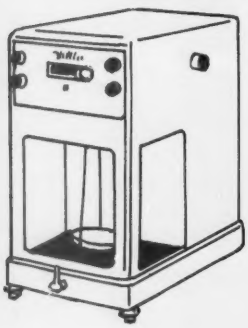

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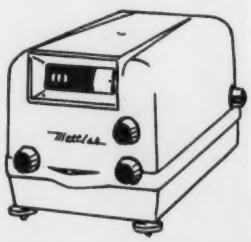

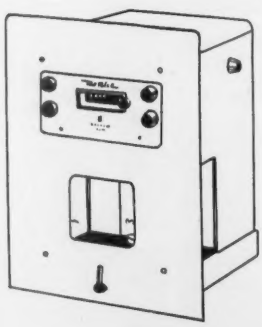

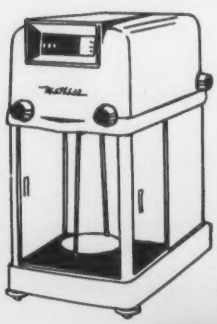

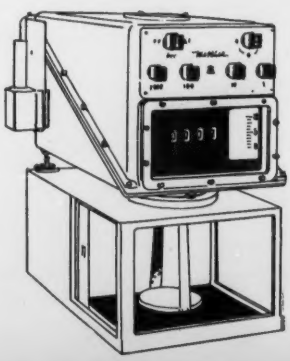

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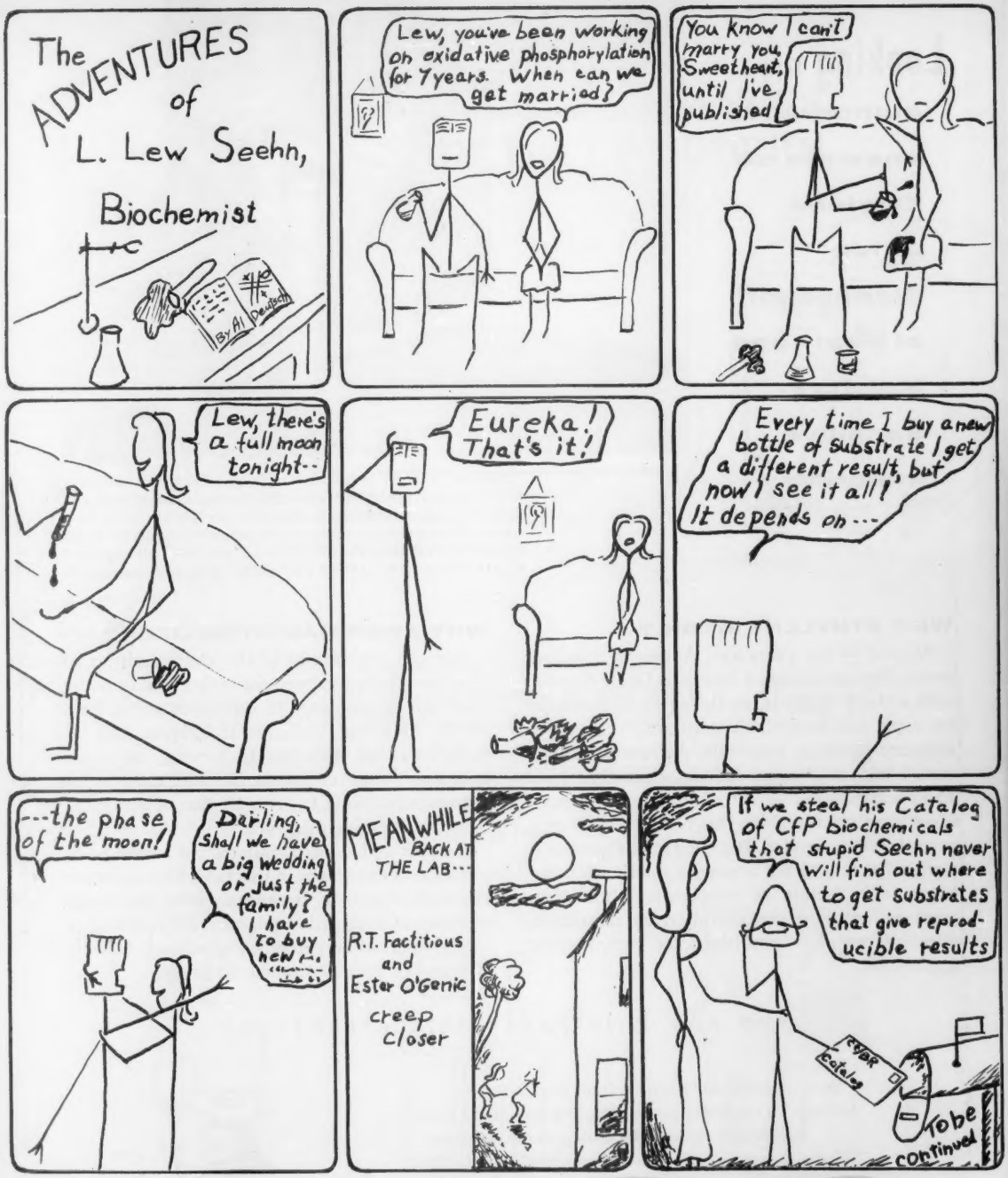

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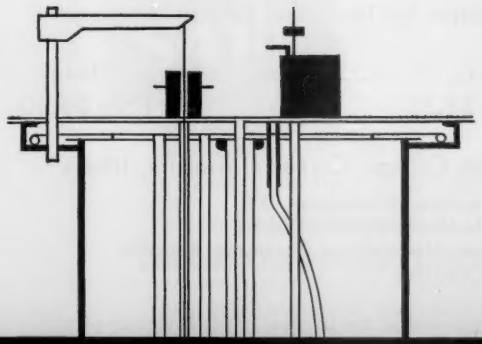

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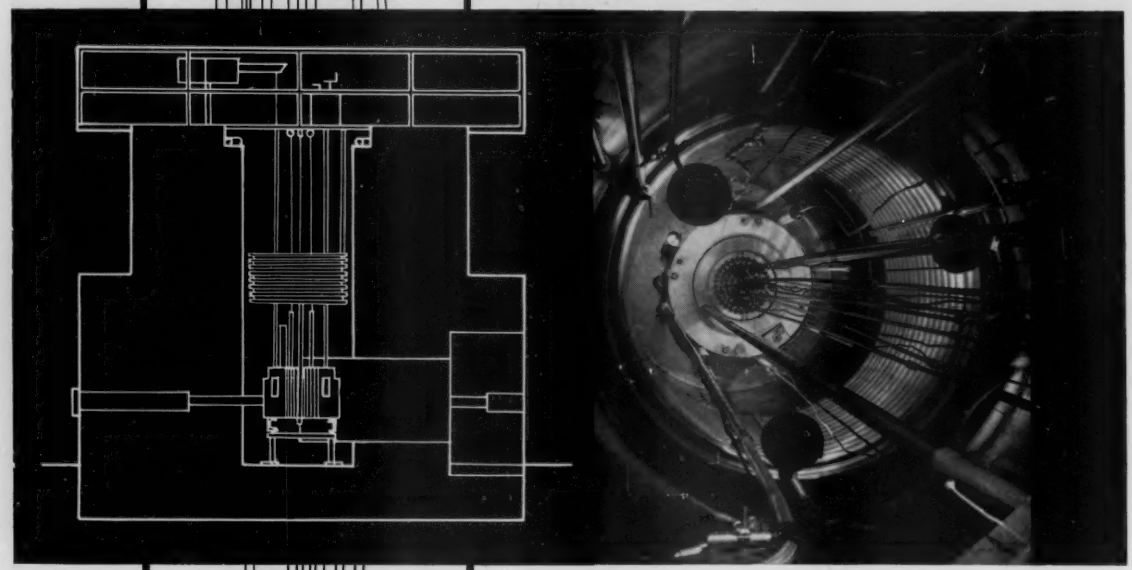
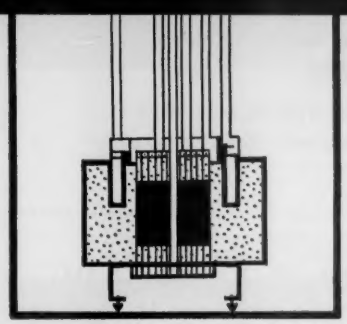
These tests included power runs at more than 10 times the reactor's design continuous power rating of 10 kilowatts. They conclusively verified the inherent safety of this new training, research and isotope-production reactor, which was conceived and developed by General Atomic.





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SCIENCE

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How Big Is Too Big?

As the national volume of research increases, and, indeed, as we experience a mounting rate of increase, a number of research organizations are growing, or may already have grown, to such dimensions that one is bound to inquire: How big is too big?

There is of course no tidy or universal answer. But there may nevertheless be some criteria which should be in the minds of those who face this question.

An organization is clearly too big if an excess of enthusiasm, energy, and hope has resulted in an expansion whose financing is so shaky that it impairs morale, or whose physical facilities are so crowded that research efficiency has suffered.

An organization should not grow further if it can do so only by using the perhaps illusory attraction of its size, resources, and prestige to rob other organizations of personnel which might, in terms of the total national effort, better stay where they are. In addition, the financial support necessary for the further expansion of a large institution may, under some circumstances, be obtained only at the expense of funds which should in fact go to other institutions.

Any enlargement of an organization is achieved only at a cost—of money, of facilities, and of personnel, all of which might otherwise be utilized elsewhere in other tasks. On the other hand, an organizational enlargement is presumably always designed to produce new benefits. Only when these benefits clearly promise to outweigh the total cost, as judged unselfishly and broadly, is the expansion justified. No one can draw up a precise profit-and-loss statement for such a transaction, but he can at least attempt to weigh all the factors.

As growth occurs it is inevitable that there will be increasing complications of organization, increasing difficulties of internal communication, and increasing inefficiency in the direct and detailed contact between the upper levels of leadership and the active research at the laboratory bench. An organization has already outgrown its optimum size if these unfortunate results of growth have combined to bring it about that the whole is no longer more than the mere sum of the parts.

There are doubtless further important criteria for judging overgrowth of an organization. It is thus to be hoped that others will add to the discussion of this topic.—WARREN WEAVER, *Rockefeller Foundation, New York.*

18 July 1958, Volume 128, Number 3316 SCIENCE

Plant Communities

Recent research suggests that they form units in a vegetation continuum rather than discrete classes.

Robert P. McIntosh

One of man's early perceptions of nature was of the variety of the vegetational mantle which covers the earth's surface. Long and intimate contact with specific types of vegetation has colored the ways of life and attitudes of a people, influenced its art, and provided a backdrop for its legends and literature. Herb doctors of the past and present search for desired plants in familiar settings, and colonial farmers recognized, in some cases erroneously, some aggregations of plants as indicators of desirable farm land and others as indicators of barren land. Our languages contain many words which refer, more or less specifically, to familiar and distinctive groups of plants. *Marsh, moor, fen, bog, brake, steppe, prairie, llano, pampas, heath, chaparral, maquis*—all indicate the widespread recognition of distinctive vegetation types which are part of man's natural heritage.

Earlier Views of Plant Communities

Prior to the 19th century, botanists, in much the same way as laymen, recognized and were familiar with diverse types of vegetation. It was not, however, until the middle of the 19th century that plant communities were consciously made objects of study. Extensive explorations of areas of the world then little known to Europeans had centered attention on the wonderful diversity of plants, and the vast primeval areas of vegetation newly viewed by naturalists stimulated attempts to describe and name them. A branch of botany called plant physiognomy arose, based upon the recognition of plant communities by their general appearance.

One of its early proponents was Anton Kerner, whose book *The Plant Life of the Danube Basin* explicitly voices the concept of plants as members of distinct communities. "Every plant has its place, its time, its function and its meaning. In every zone, plant life has been developing through an inconceivably long time according to the same pattern to build up its green structure over the naked earth. In every zone the plants are gathered into definite groups, which appear either as developing or as finished communities, but never transgress the orderly structure and correct composition of their kind" (*1*). Kerner's book was a subjective and esthetically appreciative description of the vegetation of the Danube Basin, interpreting the distribution of several physiognomically distinct "plant formations" as related to the environment. In North America such comprehensive study of vegetation lagged, although descriptions of vegetation by travelers and early botanists are numerous, and the insights of naturalists, such as Thoreau, into some aspects of the plant communities of their native areas, foreshadow the work of early plant ecologists (*2*).

Problems of Classification

It was not until the early years of the present century that intensive studies were made of the composition, distribution, development, and biological interrelations of plant communities. These studies brought to light many units of vegetation not previously recognized or dignified by name, and the list of plant communities grew rapidly. Description and naming are but the first steps in classification. As the number of described communities proliferated, systems of classification were erected analogous to those used by taxonomists. These classifications sought a basic unit or community, comparable to the taxonomic species, which would serve as a basis for a hierarchical classification of vegetation. The communities were commonly called "associations," the concept resting upon the mutual occurrence or association of species populations in recognizable communities defined by their floristic composition.

Unfortunately, there was little agreement among botanists about the nature and extent of the association or the precise basis upon which it should be defined. In some systems the association was recognized by specific combinations of the largest and most conspicuous plants, known as dominants. Trees are the obvious dominants of forest communities while grasses are the prairie dominants. In other instances the total species composition was used, certain character species, which occurred in a given proportion of the examples studied, serving to define the association.

The earlier work, based largely upon the subjective judgments of individual botanists familiar with the vegetation of an area, was soon supplemented by quantitative studies based on objective sampling techniques which described more precisely the characteristics and composition of communities. These studies served to multiply the difficulties of classification, for instead of having only combinations of species to consider, it became necessary to consider the relative frequency with which the species occurred. A community with the composition 75 percent species A, 20 percent species B, and 5 percent species C may not be in the same category as one with the composition 75 percent species C, 20 percent species B, and 5 percent

The author, until recently a member of the staff of the plant science department at Vassar College, is now on the staff of the biology department at the University of Notre Dame, Notre Dame, Ind.

species A. A multiplicity of communities of various degrees of complexity and size were described as associations, presumably all fairly distinct, one from another. Still, there was no unanimity of opinion about how much variation was permissible within an association, and the question was posed by Stanley Cain, "How many species must remain to preserve the identity of the association?" (*3*).

Great diversity existed in the associations described by botanists applying the precepts of various schools of thought. According to some schools, particularly in Europe, an association was a small-scale, homogeneous community which in some cases might be hidden under a Stetson hat (for example, a community of mosses). In America (notably as developed in the work of the pioneer ecologist Frederick E. Clements, whose views dominated American ecology for many years), an association was a large-scale unit including great variation (*4*). Moreover, according to Clements' concepts the association was comparable to an organism and was held to possess an overall unity and stability under the control of climate. As a consequence of these divergent viewpoints it was possible for Conard (*5*) to recognize 71 associations on central Long Island, while Clements recognized only three in the entire eastern deciduous forest formation of North America. These differences, aggravated by semantic difficulties, resulted in near chaos, and some ecologists advocated abandoning the term *association*, if not the concept.

In spite of these difficulties, an almost unanimous opinion existed in Europe and America that, however nebulous the thinking or however great the differences of opinion, describable aggregations of plants occur, possess boundaries in nature, and can be recognized as rather discrete entities which are repeated in numerous individual instances in the vegetation of an area. This view of vegetation as composed of discontinuous assemblages of plants or unit communities is one of the cornerstones of classical plant ecology. Associations have been variously defined, usually in the following vein: "An association is a plant community of definite floristic composition, presenting a uniform physiognomy, and growing in uniform habitat conditions" (*6*); or, "Associations of plants on land are definable entities susceptible of naming and classifying" (*7*).

The Individualistic Hypothesis

Diametrically opposed to this consensus was the hypothesis advanced by Henry A. Gleason, tentatively in 1917 and more explicitly in 1926, which he referred to as "the individualistic concept of the plant association" (*8*). Gleason maintained that plant species were distributed according to their individual biological potentialities and that the aggregation of plants on any area was the fortuitous result of the local environment and the available plants. He stated that the environment varies continuously in space and time and that vegetation also varies continuously in space and time. Therefore, similarity of individual examples is approximate only, and a precisely logical classification is impossible. Although Gleason recognized the existence of large-scale areas of vegetation, such as grassland and deciduous or coniferous forest, he emphasized that within the matrix of such physiognomically distinct areas the differences between individual communities were cumulative, so that the variation increased with the distance separating them. He cited the forests along the Mississippi River basin and noted how small changes from mile to mile, as species drop out or appear, cumulate, so that over many miles an almost complete change in composition results. His thinking was not unique, for similar ideas were expressed by various European botanists.

Thus, two apparently antithetical concepts of plant communities were in the field. The first maintained that "the juxtaposition of plants in communities is not only an empirical generalization. The association of individuals and species is much more than a chance meeting. It is a part of the order of nature" (*7*). The second held that "each separate community is merely one minute part of a vast and ever-changing kaleidoscope of vegetation, a part which is restricted in its size, limited in its duration, never duplicated except in its present immediate vicinity and there only as a coincidence, and rarely if ever repeated" (*9*).

In America the individualistic concept of plant communities was nearly dormant for 20 years. Within the past decade new evidence from varied sources has revived and added credence to the individualistic concept. Studies of vegetation types as varied as the shad scale of Nevada and California (*10*), the forests and prairies of Wisconsin (*11, 12*), and the forests of the Great Smoky Mountains (*13*) lead to conclusions substantiating the individualistic concept. Concomitant with this has been an increased interest in order or pattern among units as against a system of classification of discrete entities.

The basic question is whether or not species populations occur as groups which are discontinuous with other groups and recognizable as a series of discrete classes. Quantitative and objective methods have been applied to varied vegetation types in a reexamination of this question. Two general approaches have been used. One, "gradient analysis"

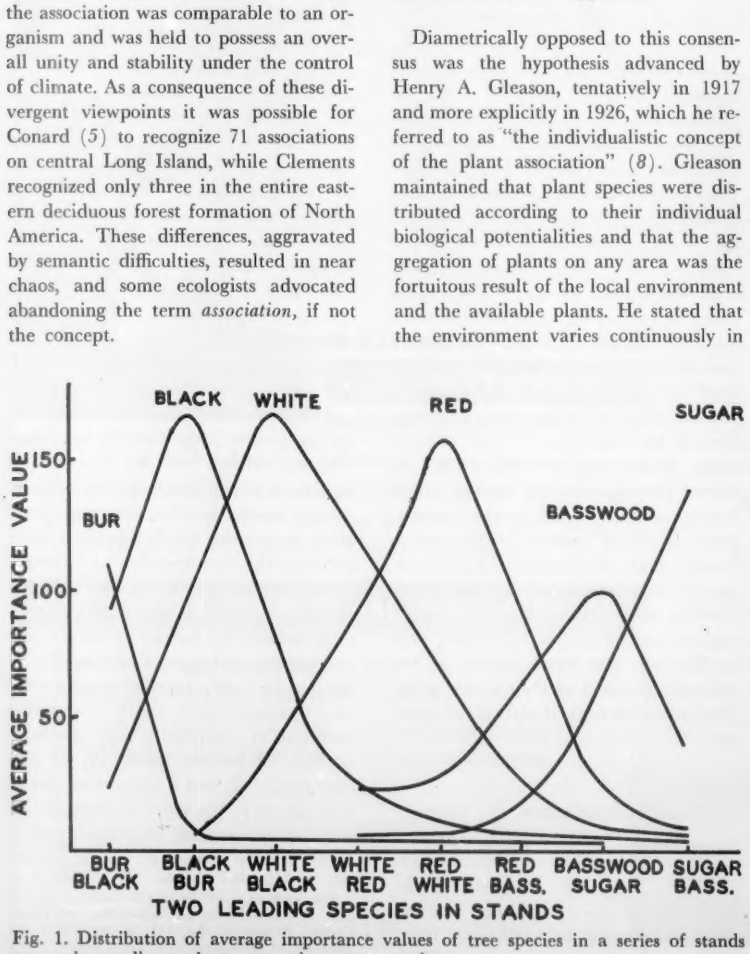


Fig. 1. Distribution of average importance values of tree species in a series of stands grouped according to the two most important species.

(*13*), examines samples of vegetation along an environmental gradient such as altitude or moisture. This gradient serves as the basis for aligning and analyzing the vegetational data. The second approach is based upon the mass collection of large numbers of samples of vegetation without reference to environmental gradients or apparent aggregations of species. The data are analyzed to ascertain species relationships which might serve as a basis for classification or the construction of gradients based upon species composition. Such compositional analysis serves to orient the individual community sample to other samples, and, conversely to the method of gradient analysis, environmental data may be aligned on a vegetational gradient.

The gradient analysis approach is the basis of forest studies in the Great Smoky Mountains by Whittaker (*13*), who collected samples spaced along gradients of altitude and moisture and also random samples throughout the area. When plant populations are analyzed according to their quantitative distribution along an environmental gradient, he finds that each species forms a bell-shaped curve. The curves are distributed along the gradient as a series with overlapping ranges, but no two curves have identical ranges or optima. No clusters of species curves are found, indicative of similar species behavior relative to the gradient and leading therefore to recognition of a series of discrete units. This, Whittaker points out, suggests that species populations form a shifting series of combinations along environmental gradients and leads to the interpretation of vegetation as a "complex and largely continuous population pattern" (*13*).

The second approach, based on the analysis of proportionate composition with respect to the dominant plants in a large number of samples, is exemplified by studies in Wisconsin forests. The relative importance of each tree species in a forest stand is denoted by its "importance value." This value is the sum of measures of density, size, and distribution derived from a series of standard samples in each stand. Density is the number of individuals of a species in the total sample. Size is measured by the cross-sectional area of the trunk of each individual tree at a standard height. The measure of distribution of the species is based on the frequency with which the species is encountered in the samples. By expressing each measure as a percentage, three relative values are obtained for each species, the sum being the importance value of the species. The magnitude of the importance value serves as an indication of the sociological importance of the species in the community. The importance values for all species in a stand add up to a constant total of 300. In a pure stand of a single species, the importance value of that species would be 300, while in the more usual stand, in which there is a mixture of species, each would have an importance value constituting some portion of 300.

In the upland forest of southern Wisconsin only four tree species—black, white, and red oaks (*Quercus velutina, Quercus alba,* and *Quercus rubra*) and sugar maple (*Acer saccharum*)—commonly attain high importance values. When stands are classified according to their most important tree species, those stands in which black oak is dominant contain decreasing quantities of white oak, red oak, and sugar maple, in that order, while, conversely, those stands in which sugar maple is the leading species contain decreasing amounts of red oak, white oak, and black oak. This suggested a preliminary order of stands, from those dominated by black oak to those dominated by sugar maple, white and red oaks being intermediate. More detailed analysis was made by classifying the stands into groups based on the two most important species. These groups were arranged in the order suggested above, additional species being placed in sequence according to the relation of the stands in which they reached optimum importance to other groups of stands (Fig. 1). This empirical ordering of groups served to demonstrate a pattern of species distribution but did not suggest anything which could be interpreted as discrete communities. It soon became apparent that the number of classes is determined by the method of selection. If the order of the four most important species of trees in a stand is used as a basis of selection, each class includes a single stand. In other words, for the data at hand, no two stands had the same arrangement of the four most important tree species, and no natural groups of species combinations were apparent.

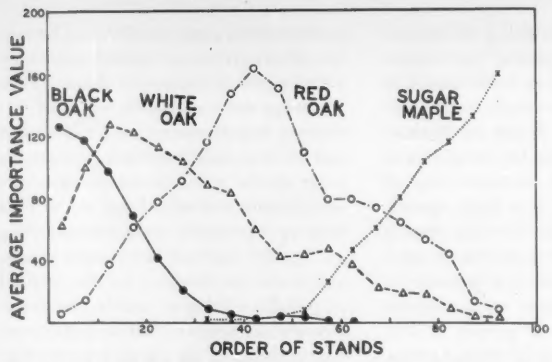
Since the groups of Fig. 1 are artificial classes, a simple method was devised for visually examining data with respect to the individual stands. The importance value of each species in a stand was marked to scale on a narrow strip of white Celluloid ten inches long. These strips could be placed side by side in any desired order, and the distribution of species among many stands could be seen at a glance. If natural groups exist, such a technique might reveal them. When the strips were placed in order of decreasing importance values for black oak and of increasing importance values for sugar maple, it was found that the species distributions of red and white oaks form approximately normal curves (Fig. 2). Species distribution of trees, shrubs, and herbs not involved in the original empirical ordering of stands also forms a continuous series of bell-shaped curves. The positions of the curves for each species are purely relative, but each occupies a characteristic position in an ordered sequence, no grouping of curves being evident. The entire order or sequence is called a vegetational continuum, for at no point can it be divided except on the basis of arbitrary criteria. The vegetational continuum represents a shifting series of species combinations in a linear pattern or gradient. Any stand is similar to, but slightly different from, its neighbors in the continuum, the difference between the stands increasing roughly as the distance between them.

Similar vegetational continua have been arrived at by using data for herbaceous plants rather than trees and by ordering the stands according to statistical measures of similarity of the species composition (*12, 14, 15*).

The concept of correlated change of species composition on a continuous gradient has its counterpart in the catena concept of the soils scientist, in which properties of soils are similarly conceived of as varying continuously. It has been compared to the spectrum of visible light. The extremes of red, yellow, green, or blue are readily apparent, but the intergradations are not so easily distinguished. The visible extremes are analogous to the conspicuously different areas of vegetation, such as prairie, oak forest, or maple forest, while the many intergradations between these extremes of vegetation suggest the continuous variation of the spectrum. The physicist designates a point or range on the spectrum not by color but by a number indicating its wavelength. Analogously, scales or index numbers have been developed to locate a given stand more precisely in a continuum.

Continuum Index

Various devices have been used to establish numerical scales to place individual stands in a vegetational con-



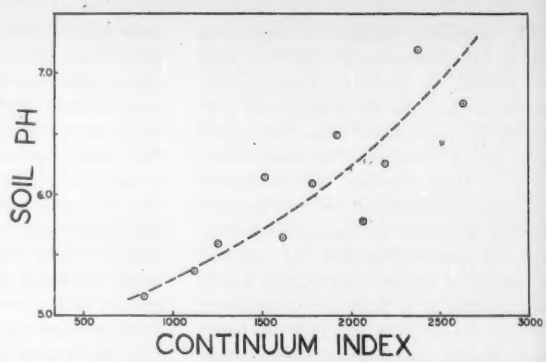


Fig. 2 (left). Distribution curves for four important tree species when individual stands are arranged in order of decreasing occurrence of black oak and increasing occurrence of sugar maple. The importance values are averaged by successive groups of five stands, and the curves are smoothed according to the formula $(a+2b+c)/4$. Fig. 3 (right). Distribution of soil *p*H in southern Wisconsin forest stands according to the continuum index.

tinuum. In the case of the continuum described above, the tree species illustrated in Fig. 2 were rated; sugar maple was used as a standard and given the arbitrary value of ten. Other species received values ranging from one to nine, according to the position of their optimum occurrence relative to sugar maple. Black oak, for example, was assigned a value of two; white oak, four; and red oak, six. The importance value of each species in a stand was multiplied by the assigned value, and the products were added. The weighted total served to place the stand in relation to other stands on a numerical scale ranging from 300 to 3000. A stand composed entirely of bur oak, which was assigned a value of one, would have a rating of 300; a stand composed solely of sugar maple, with its assigned value of ten, would have a rating of 3000. All of the species in a mixed stand would affect the total for that stand, but the species having high importance values would naturally exert the greatest influence. This scale of weighted numbers is called the vegetational continuum index. The stands originally arbitrarily classified into groups or arranged in an order of individual stands may now be arranged on the basis of index values. The order and relative position of species curves remains the same, indicating that the linear sequence is preserved in the index order.

A vegetational continuum index is a new and useful tool in ecological studies of many kinds. Distribution of environmental factors may be related to the index, as illustrated in Fig. 3, which indicates interrelations of the community complex and factors of the physical environment. The vegetation can serve as a basis for analysis of the environment. Ecological studies of individual species in stands representative of various ranges of the index serve to illustrate variation in physiological and morphological characteristics as they are related to the index (*16*). Studies of soil microfungi (*17*) indicate that species and genera are preferentially distributed in given ranges of the continuum. The penicillia, for example, increased in percentage of total species toward the higher values of the index, while the Mucorales showed a reverse trend. Like the trees, forest soil microfungi form a series of changing species combinations along the continuum gradient. Hale (*18*) found that the most satisfactory method of analyzing the distribution of mosses and lichens growing on the bark of trees was on the basis of the vegetational continuum. Although host specificity resulted in a high degree of interspecific correlation, this was found to be relative and to be modified by position on the continuum index. Populations of breeding birds in stands spaced along the continuum index demonstrate, in many cases, graded responses of individual bird species and a continuous shift of species combinations (*19*). In short, the continuum index can provide a background for studies of varied kinds of organisms, particularly studies of characteristics which may be influenced by variation in community composition.

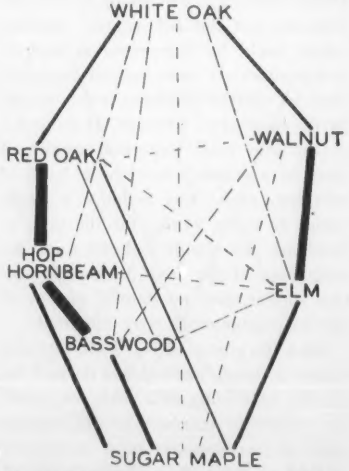


Fig. 4. Diagram illustrating interrelations among several tree species, constructed on the basis of Cole's index of interspecific association (*21*).

Community Pattern

In the development of the continuum concept it became apparent that this concept is not limited to a linear order but is multidimensional. One suggestion of this comes from a study of an area including species usually recognized as members of different forest associations (oak–hickory and maple–basswood). The composition of this stand was sampled intensively by means of a grid of quadrat (square area) samples (*20*). The mutual occurrences among the species were measured by means of an "index of interspecific association," developed by Cole (*21*). The index was computed for each of the possible species combinations. The index values range from + 100 percent for species which always occur together to – 100 percent for species which never occur together. If there is only chance association the index is zero. In the resulting matrix of indices of association between tree species it was notable that two species which are significantly associated with each other do not necessarily have similar association values with a third species. This is graphically shown in Fig. 4. In the figure, species pairs

which have a positive index of association are connected by a line whose width is proportionate to the measure of association. Those pairs which have a negative value are connected by a dashed line in which the length of the spaces relative to the length of the dashes indicates the degree of negative value. Thus, walnut (*Juglans nigra*) and hop hornbeam (*Ostrya virginiana*), which had an index value of −100, are not connected at all. Sugar maple and white oak, having an index value of −62, are connected by a line that is 38 percent dash and 62 percent intervening space.

Red oak and walnut are both associated with white oak and in similar degree, as measured by the index, but are significantly disassociated themselves. White oak, walnut, and perhaps red oak might be suggested as a possible community, but the fact that red oak and walnut are significantly disassociated would suggest two communities. Or, sugar maple, basswood (*Tilia americana*) and hop hornbeam might be regarded as a community, but the significant association of red oak and hop hornbean would suggest that red oak also be included. Elm (*Ulmus rubra*) occurs with sugar maple and might be added to such a community, but elm and red oak and elm and hop hornbeam are significantly disassociated. It seems reasonable to view such a diagram as representing an arrangement of species combinations which are connected in a continuous two-dimensional pattern. It does not seem possible to reduce the pattern to discrete communities except by introducing arbitrary lines. The pattern emphasizes the fact that a continuous relationship between species is not a linear one, as the earlier figures might suggest, but is more complex and multidimensional. Species which occupy related positions in a linear order from white oak to sugar maple may occupy quite unrelated positions on other possible axes.

Grassland and Transition

The concept of continuously varying species combinations, as postulated by Gleason's individualistic hypothesis and borne out in the forest studies described above, has proved valid in studies of grassland and transition between forest and prairie.

Dyksterhuis (*22*) has shown a continuously varying composition in Western range land. Curtis (*12*) has constructed a prairie continuum index for Wisconsin prairies, based on five groups of indicator species ranging from species with optimum development in wet sites to those showing optimum development in dry sites. An index value for each prairie stand was calculated by multiplying the relative amount of each indicator group present by a weighting value for each group and adding the weighted products. When the stands were arranged in the order of index values, for all species, including nonindicator species, there were smooth curves of occurrence in a continuous series. Identical results were obtained in a direct gradient-analysis approach when species distributions were plotted on a gradient of capacity for retention of soil water.

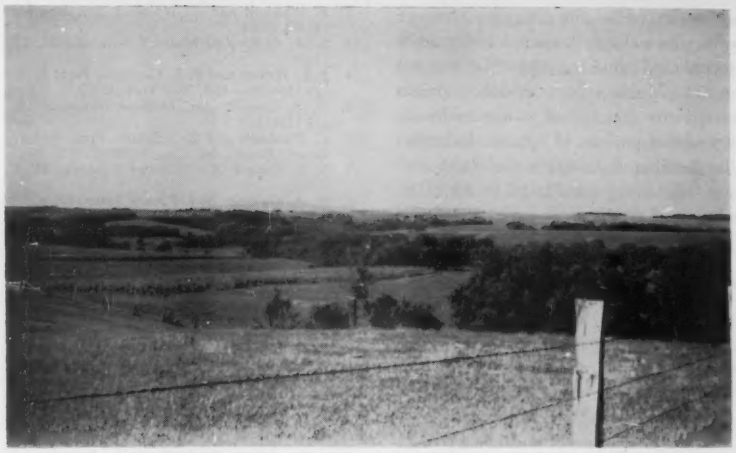


Fig. 5. Transition between prairie and forest. Here in the prairie-forest border region, forests appear in the draws; the upland, which is now cultivated, was originally largely prairie.

The work of Bray (*14*) is of particular interest. Working in the prairie-forest border region of Wisconsin, a broad intermediate belt between grassland and forest, he finds evidence of continuous transition between forest and prairie. In this region prairie and forest were originally intermingled in a mosaic of vegetation now almost universally disrupted by cultural activities (Fig. 5). Although prairies are found on various land forms, they commonly occur on rolling uplands and steep hills, and it is on the latter that many of the remnants are found in the prairie-forest border. Bray established a transect of samples extending from prairie into forest. He describes his findings as follows: "Here is the vegetation of two formations coming together within the oak opening transition of the prairie-forest border and interlocking so smoothly that of those species which reach their greatest frequency within the oak opening . . . it is difficult to state whether they are primarily forest plants or prairie plants."

The concept of continuity in vegetation is not at odds with any but the most fundamentalist views of the integrity of the associational unit. Practically all ecologists recognize the existence of intergrading areas of composition and characteristics between stands which may be described as representative of different associations. J. Braun-Blanquet (*23*), whose work is commonly regarded as the archetype of classification of vegetation into associations, states: "The possible combinations of species are indeed endless." The essence of the continuum approach as an outgrowth of the individualistic concept is to switch the emphasis from the study of more or less similar units of vegetation with admitted intergrades to the study of the gradient itself. As Goodall (*24*) has pointed out, nothing will be lost, for any cluster of species which responded as a unit would still appear, and information about the reaction of species in zones now regarded as transitional would also be available. The logic of proceeding on an assumption of continuity of vegetation unless discontinuity is clearly demonstrated seems clear, in view of the confusion of opinions on association concepts.

The concept of plants as members of communities stated by Kerner and many others is substantiated in the work of modern plant ecology. The order inherent in nature is not, however, one of clear-cut cause and effect relationships re-

sulting in well-defined aggregations of species into clearly bounded and readily pigeonholed units as objective natural entities. Much recent evidence points toward the concept of communities as an ordered pattern of species, individually distributed in space and time and most effectively considered in terms of orders and gradients.

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Folic Acid Coenzymes

Metabolic reactions involving "active formate" and "active formaldehyde" are surveyed.

F. M. Huennekens, M. J. Osborn, H. R. Whiteley

For a great variety of cells of animal, plant, and microbial origin, the vitamin, folic acid, serves as a growth factor by controlling the metabolism of the one-carbon (C_1) compounds, formate and formaldehyde. These C_1 compounds serve as building blocks in the biosynthesis of purines, certain pyrimidines, and certain amino acids. An increased capacity to incorporate formate into cellular nucleic acids (*1*), and also an elevated level of folic acid (*2*) and its coenzyme forms (*3*), has been found to characterize at least one type of abnormal growth, namely that of the leukemic white cell.

A description of C_1 metabolism is provided by the following generalized equations for the mobilization of *X*, the formaldehyde or formate group,

$$D—X + C \rightleftharpoons C—X + D \qquad (1a)$$

$$C—X + A \rightleftharpoons A—X + C \qquad (1b)$$

In these equations, *C* is the folic acid coenzyme, *D* is a donor molecule containing a potential C_1 unit (serine, purine, histidine, and so on), and *A* is an acceptor molecule (glycine, carboxamide ribotide, and so on). When the C_1 unit is bound to the folic acid coenzyme (*C—X*), the complex may be considered as "active formate" or "active formaldehyde," respectively; the latter complex is more frequently referred to as "active hydroxymethyl." The analogy between these complexes and the well-known "active acetate" (acetyl coenzyme A) is apparent.

Although the early recognition of various metabolites as donors and acceptors of formyl and hydroxymethyl units was achieved by tracer and nutritional studies (*4, 5*), recent work has been directed toward studies with isolated enzyme systems, which permit a greater degree of understanding of reaction mechanisms. Study of the detailed mechanisms of the various reactions, represented by Eqs. 1a and 1b, has been hampered by the multiplicity of the C_1 fragments (formyl, hydroxymethyl, and in some instances, methyl) and by uncertainty concerning the chemical structure of the intermediates, *C—X*, since, as is discussed in subsequent paragraphs, folic acid has several potential sites of attachment for a C_1 group.

In this article (*6*) we shall attempt to summarize the current information regarding the nature of "active formyl" and "active hydroxymethyl" complexes and to survey the various metabolic reactions in which these compounds participate (*7*).

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Reactions Involving "Active Formaldehyde"

Serine hydroxymethylase. Numerous investigators (summarized in reference *8*) have studied the enzymatic interconversion of serine and glycine. In early work (*9*), in which tissue slices or intact animals were used, sensitive tracer techniques were required to detect the small conversions. More recently, larger conversions have been achieved by use of purified enzymes from avian and mammalian livers (*8*; *10–13*).

The over-all reaction (Eq. 2) for the biosynthesis of serine from glycine and HCHO

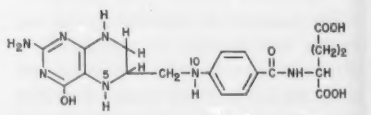
$$\text{HCHO} + \text{glycine} \rightleftharpoons \text{serine} \qquad (2)$$

is actually the sum of two separate reactions

$$\text{HCHO} + \text{FH}_4 \rightleftharpoons \text{hFH}_4 \qquad (2a)$$

$$\text{hFH}_4 + \text{glycine} \rightleftharpoons \text{serine} + \text{FH}_4 \qquad (2b)$$

where FH_4 is the abbreviation (*14*) for 5,6,7,8-tetrahydrofolic acid (I)



I

the coenzyme form of folic acid, and hFH_4 symbolizes hydroxymethyl FH_4, without specifying the position of the C_1 group on the folic acid coenzyme.

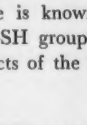
Reactions 2a and 2b are catalyzed by the formaldehyde-activating enzyme and serine hydroxymethylase [or serine aldolase (*11*)], respectively.

In the over-all reaction (Eq. 2) a requirement for pyridoxal phosphate has been observed in all systems studied (*8*; *10–13*; *16*); an additional requirement for Mn^{++} has been demonstrated only with a bacterial enzyme (*15*). The site of action of both cofactors is undoubtedly in reaction 2b, as would be anticipated from the chemical studies of Snell and his co-workers (*16*).

Formaldehyde-activating enzyme. Since spectroscopic evidence indicates that HCHO and FH_4 interact rapidly in the absence of any enzyme to form one or more complexes, it was not immediately clear whether reaction 2a was enzyme-catalyzed or not. However, during purification of the enzyme system that catalyzes reaction 2, it was found that the enzymes for reactions 2a and 2b could be partially separated (*13*). The formaldehyde-activating enzyme can be assayed in the following manner. When FH_4 ($\lambda_{max.}$ at 300 mμ, $\varepsilon \cong 22 \times 10^6$ cm²/mole) is mixed with a slight excess of HCHO at *p*H 7, no reaction occurs. When the purified activating enzyme is added, the spectral peak shifts to 294 mμ, and ε increases to 26×10^6 cm²/mole. This shift is due to the formation of hFH_4 according to Eq. 2a. When hFH_4 is synthesized enzymatically, it is a reasonably stable substance and can be separated from unreacted FH_4 by column chromatography or by paper chromatography (*17*).

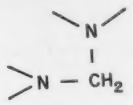
The authenticity of hFH_4 is established by the following enzymatic assays. (i) In the presence of serine hydroxymethylase and glycine, hFH_4 disappears and FH_4 reappears (see reactions 2b). (ii) In the presence of the hFH_4 dehydrogenase (see below) and TPN, hFH_4 is oxidized to formyl FH_4, and an equivalent amount of TPNH is formed. Non-enzymatically, hFH_4 may be converted to FH_4 by the addition of hydroxylamine in acid; in a basic medium the material is stable to H_2NOH.

Structure of "active formaldehyde." Formaldehyde is known to react with —NH_2 or —SH groups, forming equilibrium adducts of the type represented by II.



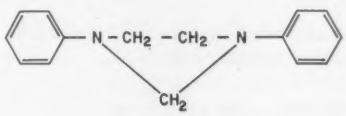
II

When a second ligand is possible with the bound HCHO, as in III,



III

much more stable complexes are formed, especially if both ligands are on the same molecule. An example of this is the reaction of HCHO with cysteine to form the stable heterocycle, thiazolidine carboxylic acid. An important clue to the structure of hFH_4, was provided by Blakley (*18*), who prepared the HCHO adduct (IV) of N,N-diphenyl ethylenediamine:



IV

Structure IV is quite stable, and, like thiazolidine carboxylic acid, it does not release its bound HCHO to aldehyde-binding agents such as chromotropic acid and acetyl acetone. Although hFH_4 in acid behaves like a type II adduct in releasing HCHO, its stability in base strongly suggests a type III structure, very probably $h^{5\text{-}10}FH_4$ (*19*). Confirmatory evidence for this proposed structure comes from a study of the substrate specificity of the hFH_4 dehydrogenase, as described below.

While HCHO and FH_4 react rapidly in the absence of enzyme to form a product which is active in systems requiring hFH_4, the reaction is not confined to a single product as in the enzymatic synthesis. Various spectroscopic complexes, whose $\lambda_{max.}$ range between 290 and 300 mμ, are formed when increasing amounts of HCHO are added to FH_4. This result is not unexpected, for FH_4 contains several potential sites, namely, the N^3, N^5, N^8, and N^{10} positions, for binding HCHO.

Reactions Involving "Active Formate"

Hydroxymethyl tetrahydrofolic acid (hFH_4) dehydrogenase. The metabolic equivalence of formyl and hydroxymethyl donors in early tracer studies of C_1 reactions (that is, the labeling of the C-2 position of the purine ring both by formate and by the β-carbon atom of serine) presupposed the existence of a system for the interconversion of the two oxidation states. A TPN-linked dehydrogenase, carrying out this interconversion, was first described by Jaenicke (*20*) and by Greenberg *et al.* (*21*) and was later obtained in purified form in our laboratory (*22*). The over-all reaction is shown in Eq. 3.

$$hFH_4 + TPN^+ \rightleftharpoons fFH_4 + TPNH + H^+. \quad (3)$$

For the moment, the precise nature of hFH_4 and fFH_4 is not specified. Reaction 3 is best studied in conjunction with reactions 2b or 2a, serine or HCHO being used to generate hFH_4. When crude dehydrogenase preparations are used, the accumulated reaction product, fFH_4, is the N^{10}-isomer, $f^{10}FH_4$. However, when dehydrogenase preparations are freed from the enzyme, cyclohydrolase (*23*), which carries out reaction 4,

$$(f^{5\text{-}10}FH_4)^+ + H_2O \rightleftharpoons f^{10}FH_4 + H^+ \quad (4)$$

the end product of reaction 3 is $f^{5\text{-}10}FH_4$. With purified dehydrogenase preparations, $f^{5\text{-}10}FH_4$, but not $f^{10}FH_4$ or f^5FH_4, serves as a substrate for reaction 3 in reverse. Similarly, $f^{5\text{-}10}FH_4$ (but not f^5FH_4 or $f^{10}FH_4$) can be reduced quantitatively with borohydride, and the product is identical to authentic hFH_4 as measured by absorption spectrum and enzymatic assays. The experiments cited above provide support for the hypothesis that both hFH_4 and fFH_4 in reaction 3 are the N^5, N^{10}-bridge compounds. Greenberg and Jaenicke (*7*) and Kisliuk (*24*) have also suggested that hFH_4 is $h^{5\text{-}10}FH_4$.

The equilibrium constant for reaction 3 is near unity at *p*H 8.0 (the *p*H optimum for the enzyme), and the extent of the reaction is dependent, of course, upon H^+. This can be demonstrated by starting with $f^{10}FH_4$ (in the presence of cyclohydrolase) and following the disappearance of TPNH spectrophotometrically at 340 mμ. After the equilibrium position has been established, the reaction may be driven further to the left, as evidenced by further disappearance of TPNH, by the addition of H^+, or by the addition of glycine (to "trap" hFH_4 via reaction 2b).

In addition to facilitating the interconversion of C_1 units at the levels of formyl and hydroxymethyl, the dehydrogenase can be used as a spectroscopic "marker" for following a variety of re-

actions (see Fig. 1) that involve hFH_4 or fFH_4. Furthermore, the equilibrium of the dehydrogenase itself (and, of course, any coupled system involving the dehydrogenase) can be manipulated in either direction—for example, by trapping TPNH via the glutathione reductase system or by trapping TPN with glucose-6-phosphate dehydrogenase.

N^{10}-formyl tetrahydrofolic acid ($f^{10}FH_4$) deacylase. Studies with the dehydrogenase in beef and pigeon liver preparations led to the discovery of a deacylase (*25*) specific for $f^{10}FH_4$:

$$f^{10}FH_4 + H_2O \rightarrow HCOOH + FH_4 \quad (5)$$

This enzyme is present in beef liver preparations but absent from pigeon liver preparations. When the dehydrogenase was studied with the latter tissue, the amounts of TPNH and $f^{10}FH_4$ formed during the reaction were equal. With the former tissue, the amount of accumulated $f^{10}FH_4$ was much less than the TPNH because of the concomitant action of the deacylase. The deacylase has been partially purified from beef liver preparations; it can be added to pigeon liver dehydrogenase to produce the beef liver pattern (that is, TPNH » $f^{10}FH_4$). A more simplified assay for the deacylase consists of incubating $f^{10}FH_4$ (absorption maximum at 258 mμ) directly with the enzyme and measuring the increase in optical density at 300 mμ as FH_4 is produced. Since small quantities of formate are difficult to estimate, the stoichiometry of reaction 5 has been studied with respect to FH_4. 5,6,7,8-Tetrahydrofolic acid (FH_4) has been identified by its activity with the formate-activating enzyme (see below) and by its activity in the coupled hydroxymethylase-dehydrogenase system:

$$\text{Serine} + FH_4 + TPN^+ \rightleftharpoons \text{glycine} + f^{10}FH_4 + TPNH + H^+ \quad (6)$$

The deacylase for $f^{10}FH_4$ probably serves to regenerate FH_4 in the absence of actively functioning acceptors for "active formyl," much as the deacylase for acetyl coenzyme A provides a means for regenerating coenzyme A in the absence of acceptors for "active acetate."

Formate-activating enzyme. Since free formate has long been known to enter metabolic systems involving "active formyl" and "active hydroxymethyl" groups, it was anticipated that there would be a formate-activating enzyme. Formate activation was first reported (*21, 26*) in connection with studies of the biosynthesis of purines, and the following stoichiometry was proposed:

$$HCOOH + ATP + FH_4 \xrightarrow{Mg^{++}} f^{10}FH_4 + ADP + P_i \quad (7)$$

The formation of ADP and P_i as end products makes this reaction similar to the activation of glutamate or succinate. In contrast, the activation of other carboxylic acids, such as acetate or butyrate, produces AMP and PP as end products. Using a highly purified activating enzyme from *Micrococcus aerogenes,* we have shown (*27*) that the sequence in reaction 7 is

$$ATP + FH_4 \rightleftharpoons ADP + pFH_4 \quad (7a)$$
$$pFH_4 + HCOOH \rightleftharpoons f^{10}FH_4 + P_i \quad (7b)$$

The mechanism thus resembles that proposed for the formation of succinyl-CoA, where S-phosphoryl CoA is the analogous intermediate (*28*). Spectroscopic evidence has been adduced for reaction 7a; when enzyme and ATP are added to FH_4, the peak at 300 mμ shifts to shorter wavelengths, and ε decreases about 15 percent. "pFH_4," labeled with P^{32}, has also been isolated from reaction mixtures by use of ATP^{32}. Reaction 7a is also followed conveniently by measuring the liberated ADP with the coupled system employing pyruvic kinase and lactic dehydrogenase:

$$\text{ADP} + \text{phospho-enol pyruvate} \rightleftharpoons \text{ATP} + \text{pyruvate} \quad (8)$$

$$\text{Pyruvate} + DPNH + H^+ \rightleftharpoons \text{lactate} + DPN^+ \quad (9)$$

The observed reaction product in Eq. 7 is $f^{10}FH_4$. Since the purified bacterial enzyme contains no cyclohydrolase, it seems probable that $f^{5\text{-}10}FH_4$ is not an intermediate in this reaction. Consequently, it would seem most likely that the intermediate in reactions 7a and 7b, pFH_4, is N^{10}-phosphoryl FH_4 ($p^{10}FH_4$ in our symbols), but the verification of this assumption must await the unambiguous chemical synthesis of this compound.

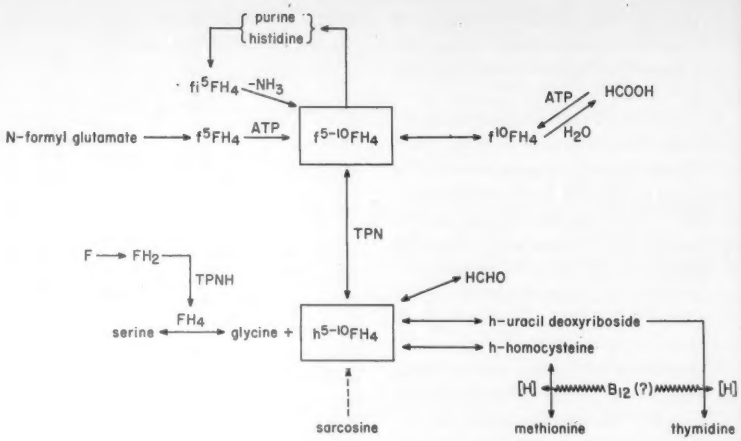


Fig. 1. Metabolic interrelationships of active C_1 units.

N^5-formyl tetrahydrofolic acid (f^5FH_4) isomerase. In all of the studies mentioned above, $f^{10}FH_4$ or $f^{5\text{-}10}FH_4$ has been involved as the "active formyl" group. The question may be raised, therefore, about the relationship of the classical formyl isomer, f^5FH_4 (folinic acid), to "active formate." Except for the formylation of glutamate (*29*), where f^5FH_4, rather than $f^{10}FH_4$ or $f^{5\text{-}10}FH_4$, is the formyl donor, folinic acid is curiously inert metabolically. There is, however, an enzyme system (*30*) present in many tissues which brings about the apparently unidirectional isomerization of f^5FH_4 to $f^{10}FH_4$ via the following reaction:

$$f^5FH_4 + ATP \xrightarrow{Mg^{++}} f^{10}FH_4 + ADP + P_i \quad (10)$$

Recent studies by Peters and Greenberg (*31*) have suggested that AMP and PP, rather than ADP and P_i, are the reaction products. It has been established (*31, 32*) that reaction 10 in certain tissues may be separated into two separate steps:

$$f^5FH_4 + ATP \rightarrow f^{5\text{-}10}FH_4 + ADP + P_i \quad (10a)$$
$$\text{(or AMP + PP)}$$

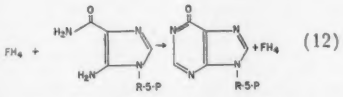
and

$$f^{5\text{-}10}FH_4 + H_2O \rightarrow f^{10}FH_4 \quad (10b)$$

Reaction 10b is catalyzed by cyclohydrolase, while the enzyme responsible for reaction 10a may be termed *cyclodehydrase*, by analogy to the *cyclodeaminase* reaction studied by Rabinowitz and Pricer (*23*):

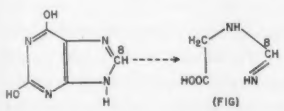
$$f^5FH_4 \rightarrow f^{5\text{-}10}FH_4 + NH_3 \qquad (11)$$

Biosynthesis and breakdown of purine and histidine. The laboratories of Buchanan (*33*), and G. R. Greenberg (*26*) have shown that both the 2- and 8-carbon atoms of the purine ring arise by the action of a specific transformylase with $f^{10}FH_4$ (or $f^{5\text{-}10}FH_4$) as the formyl donor.



(12)

In contrast, the *breakdown* of purines, at least in certain bacterial systems, is much more complicated. Cleavage of xanthine gives rise to CO_2 from the C-2 position, but the C-8 carbon emerges as the formimino group, H—C=NH, of formiminoglycine (FIG) (*23, 34*):



(13)

Formiminoglycine is then decomposed according to the sequence:

$$FIG + FH_4 \rightarrow f^5FH_4 + \text{glycine} \qquad (14)$$

followed by reactions 11 and 10b. Similarly, in mammalian liver (*35*), histidine is degraded to the analogous intermediate, formiminoglutamic acid (FIGlu), which, in turn, is metabolized by a series of reactions analogous to 14, 11, and 10b. The pathway of histidine biosynthesis has not yet been elucidated fully, although the involvement of a formyl or formimino group has been demonstrated.

Formate exchange into pyruvate. Recent reports (*36*) indicate that the exchange of $HC^{14}OOH$ into pyruvate by crude extracts of *Escherichia coli* is stimulated by the addition of FH_4. Similar results have been obtained with extracts of *Micrococcus aerogenes* and *Micrococcus lactilyticus* (*37*). However, the identity of the C_1 complex participating in the exchange reaction is not known, and the mechanism of the reaction has not been established. In the anaerobic micrococci the exchange reaction does *not* occur via serine as an intermediate—that is, by synthesis of serine from formate and endogenous glycine followed by deamination to pyruvate.

Structure of "active formate." Because of its early recognition, folinic acid (f^5FH_4) was assumed to be the "active formate" in C_1 metabolism. Subsequent work with purified enzyme systems, however, has revealed that f^5FH_4 functions only in the formylation of glutamate (*29*) and in the isomerase reaction (Eq. 10). As shown in Fig. 1, $f^{5\text{-}10}FH_4$ or $f^{10}FH_4$ is the formylating agent in all other reactions.

Interconversion of Formyl and Hydroxymethyl Groups with Methyl Groups

Although the details of the enzymatic pathways concerned with thymine and methionine synthesis are not fully known, the methyl groups of these compounds have been shown to be interconvertible with formyl and hydroxymethyl groups (*5*). It seems probable also that the transfer of the C_1 group occurs at the hydroxymethyl level rather than at the formyl level (*38*). In thymidine synthesis, uracil deoxyriboside (*39*) [or ribotide (*40*)], rather than free uracil, has been implicated as the C_1 acceptor. In methionine synthesis, homocysteine serves as the acceptor. The above reactions may be generalized in the following sequence, where *A* represents either uracil deoxyriboside or homocysteine, *h-A* the corresponding hydroxymethyl derivatives, and *m-A* the methyl derivatives:

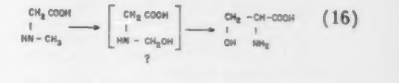
$$hFH_4 + A = h\text{-}A + FH_4 \qquad (15a)$$

$$h\text{-}A \overset{(2H)}{\rightleftharpoons} m\text{-}A \qquad (15b)$$

Both thymidine (*39, 40*) and methionine (*41*) syntheses have been studied in crude extracts, and it has been shown that the required components are (i) the acceptor (uracil deoxyriboside or homocysteine); (ii) a hydroxymethyl source and FH_4; (iii) a reducing source, usually DPN, although this may not be the actual [2H] shown in reaction 15b; and (iv) ATP, perhaps to promote the condensation in reaction 15a.

Reaction 15b is of great interest when uracil deoxyriboside is the acceptor because it seems most probable that the over-all requirement for vitamin B_{12} in thymine synthesis can be narrowed down to this step. The possibilities that the porphyrin-bound cobalt of vitamin B_{12} passes through an oxidoreduction cycle during reaction 15b deserve investigation.

The sarcosine-to-serine conversion (*42*) is also of interest, for it represents the hydroxymethyl → methyl sequence in reverse and is carried out intramolecularly:



(16)

This reaction has been demonstrated in intact mitochondria (*42*) or digitonin extracts of mitochondria (*43*), but the cofactor requirements or intermediates are presently unknown.

Biosynthesis of Folic Acid Coenzymes

The above reactions emphasize the role of reduced folic acid (FH_4) as the coenzyme, or carrier, of the C_1 groups. The formation of FH_4 from the vitamin, folic acid, has been the subject of recent investigations. Wright *et al.* (*44*) have shown in a bacterial system that folic acid is reduced to dihydrofolic acid during operation of the pyruvic oxidase. In chicken liver extracts both steps in the reduction of folic to tetrahydrofolic acid require TPNH (*45, 46*).

In our laboratory (*47*), a TPN-linked, dihydrofolic reductase has been purified from avian liver and shown to catalyze the final step in FH_4 biosynthesis:

$$FH_2 + TPNH + H^+ \rightarrow FH_4 + TPN^+ \qquad (17)$$

The equilibrium at *p*H 7 for reaction 17 lies far to the right. At extremely low concentrations (about $10^{-7}M$), the folic acid antagonists, aminopterin and amethopterin, are extremely potent competitive inhibitors of FH_2 in the reaction (*48*).

Summary

The above reactions involving "active formyl" and "active hydroxymethyl" groups, their interconversion, their connections with free HCOOH and HCHO, and their interdigitation with methyl groups are diagrammed in Fig. 1.

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Optical Tracking of Artificial Earth Satellites

The Moonwatch program and the precision photographic program supply much of the raw orbit data.

Fred L. Whipple

Mankind's curiosity in exploring the unknown and his ability to use the accumulated experience and knowledge of the race have resulted in his creation of nine astronomical bodies in the course of the past seven months. Five artificial satellites have been put into orbit about the earth, and three of these involved additional pieces of equipment that have constituted independent satellites. The fact that the life-times of these various artificial satellites are relatively short compared to the life-times of natural satellites does not detract from their astronomical significance or from the intellectual and technological achievement that they represent. All satellites, whether natural or artificial, are temporary in nature, if one chooses a sufficiently long time scale. Man-made satellites have now become so numerous that the people most intimately connected with the programs are beginning to have difficulty in segregating and recalling the individual characteristics of each one. Hence, for the convenience of both the writer and the reader, G. F. Schilling has kindly prepared Table 1, listing the major basic information concerning the identification, nature, initial orbit, and survival characteristics of these various satellites. Identification is by year, in the order of launching according to the Greek alphabet. When more than one component of a launching is optically detectable, the components are identified by Arabic numerals following the Greek letter, in order of decreasing optical brightness. Other entries of Table 1 are self-explanatory or are described in the legend.

The orbital elements of artificial satellites are subject to fairly rapid and major changes arising from the earth's deviation from sphericity and from the effect of atmospheric drag. The major effect of the earth's equatorial bulge is to produce a regression of the orbital nodes—the intersection of the equatorial and orbital planes—in a westerly direction for eastward-moving satellites such as now are aloft. The rate depends upon the orbital inclination and physical dimensions. The direction from the center of the earth to minimum distance (peri-

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Table 1. Artificial satellite parameters. Parentheses denote estimated value; "equals" sign denotes value expected to be equal to that for the component from the same launching given in preceding column. Experiments: (*a*) satellite temperatures; (*b*) meteors; (*c*) cosmic rays; (*d*) solar radiation; and (*e*) biological. [Prepared by G. F. Schilling]

Parameters	1957 α1 (Carrier rocket)	1957 α2 (Sputnik I)	1957 α3 (Nose-cone?)	1957 β1 (Sputnik II)	1957 β2 (Nose-cone?)	1958 α (Explorer I)	1958 β1 (Carrier rocket)	1958 β2 (Vanguard I)	1958 γ (Explorer III)
Launching date (U.T.)	4 Oct.	4 Oct.	4 Oct.	3 Nov.	3 Nov.	1 Feb.	17 Mar.	17 Mar.	26 Mar.
Launching time (U.T)	?	=	=	04 40?	=	03 48	12 16	=	17 38
Injection time (U.T.)	?	?	?	?	?	03 55	12 26	=	17 45
Initial period (min)	96.2	96.2	=	103.7	=	114.95*	134.29*	134.29*	115.91*
Initial apogee (km)	950	950	=	1670	=	2540	3965	3965	2800
Initial perigee (km)	225	225	=	240	=	368	652	652	188
Inclination (°)	65.3°	65.3°	=	65.4°		33.14°	34.30°	34.30°	33.5°
Eccentricity	0.051	0.051	=	0.0876	=	0.139	0.191	0.191	0.166
Length (cm)	?	58	?	?	?	200	145	16.4	200
Diameter (cm)	?	58	?	?	?	15.3	46	16.4	15.3
Weight (kg)	(2690)?	83.6	?	(3200)?	?	14	23	1.47	14.1
Payload weight (kg)		?		508.3		5	None	(1.0)	5?
Radio transmission (Mcy/sec)		40.002		40.002		108.00 FM	None	108.00	108.00
Radio transmission (mw)		1000		?		10		10	10
Radio transmission (Mcy/sec)		40.005		40.005		108.03 AM	None	108.03	108.03
Radio transmission (mw)		1000		?		50		5	50
Battery life-time (day)		21		7		60 and 11		?	60
Satellite life-time (day)	58	92	?	161	?	(3–5 yr)	(Many yr)	(Many yr)	(Months)
Effective mass-area ratio (g/cm^2)	(14.5)?	(24.1)†	?	(17.2)?	?	5.5†	3.8	3.96†	5.6 Geophysical
Instrumentation for scientific experiments	None	*a*, *b*	None	*a*, *b*, *c*, *d*, *e*	None	*a*, *b*, *c*	None	*a*	*a*, *b*, *c*

* Anomalistic period. † Antenna drag effects taken into account.

gee), moves forward (eastwardly) for inclinations below about 63° and retrograde (westerly) for greater inclinations. The nature of these motions is indicated in Fig. 1. Various periodic effects are superimposed upon these secular changes, but the equatorial bulge produces no secular terms in the semimajor axis or eccentricity of a satellite orbit.

The effect of the earth's atmosphere is to reduce the angular momentum of a satellite, the physical resistance occurring mostly in the neighborhood of the perigee because of the exponential-type decrease of atmosphere with altitude. As a consequence, the maximum, or apogee, distance of the satellite decreases more rapidly than the perigee, which remains fairly constant until the eccentricity has become rather small. Typical changes of apogee and perigee (*1*) are illustrated in Fig. 2 for an arbitrary time scale. Hence, measurements of the orbital elements of satellites can give direct information concerning the distribution of air density at high altitudes and the dynamical flattening of the earth, or the extent of equatorial bulge.

Optical and Radio Tracking

The artificial earth satellites have been put into orbit as a part of the program of the International Geophysical Year. Both radio and optical tracking have been conducted on an international basis. The U.S. National Committee of the International Geophysical Year, as a committee of the National Academy of Sciences and with the financial assistance of the National Science Foundation, has assigned to the Smithsonian Astrophysical Observatory the task of optically tracking the artificial earth satellites. The optical tracking program is under the immediate supervision of J. Allen Hynek. The program was started in 1956 and is divided into two major sections: (i) the Volunteer Moonwatch Program and (ii) the Precision Photographic Program.

The Moonwatch observers utilize small monocular telescopes, usually of aperture of 50 millimeters with a magnifying power of 6, so aligned as to form an optical fence along the local meridian or, in some cases, at other angles for best observations of satellites of high inclinations (Fig. 3). The precision photo-

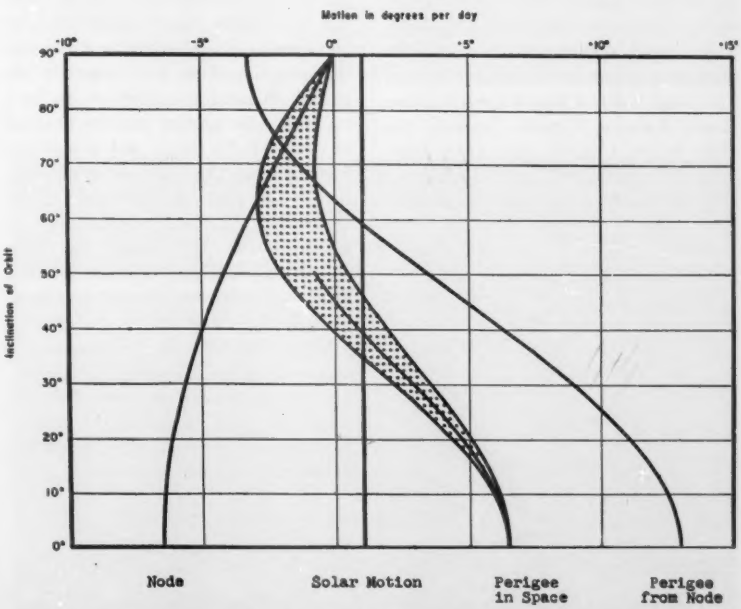

Fig. 1. Secular changes in the orbits of near-earth satellites. [Based upon calculations by L. E. Cunningham, from "The motion of a nearby satellite with highly inclined orbit," presented before the meeting of the American Astronomical Society, Berkeley, California, August 1956]

graphic system uses astronomical cameras of 20-inch aperture and 20-inch focal length, which utilize strip film of 5° by 30°. Twelve stations are planned, to be distributed around the earth between latitudes 37°N and 32°S; these were scheduled to be in full operation by June 1958. Karl G. Henize supervises the photographic program.

Project Vanguard, under the direction of the U.S. Naval Research Laboratory, bears the major responsibility of tracking the IGY satellites by radio signals originating in the satellites. Seven of nine Minitrack receiving stations, operated by the U.S. Army, are distributed near the 75th westward meridian to constitute a radio fence. A second system of radio tracking, the Microlock system, has been developed by the Jet Propulsion Laboratory of Pasadena and shares the responsibility for radio tracking. Various powerful radar telescopes have been successful in tracking the rocket stages of the Russian satellites and have contributed enormously by making observations of their death throes. Particularly important are the great 250-foot radio telescope at the Jodrell Bank Experimental Station in England, the 80-foot radar of Project Lincoln in Massachusetts, and the 60-foot radar of Stanford in California.

Of some 230 volunteer Moonwatch stations registered in April 1958, 126 are in the United States. The other stations are operated through their respective National Committees of the International Geophysical Year and include some 70 stations in Japan and a number in Australia and South Africa. Represented are South America, Central America, the East Indies, Canada, and other countries. In addition, the U.S.S.R. has organized some 70 Moonwatch stations,

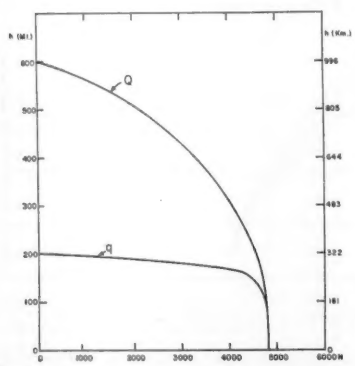

Fig. 2. Variation of perigee and apogee altitude with number of revolutions and with time.

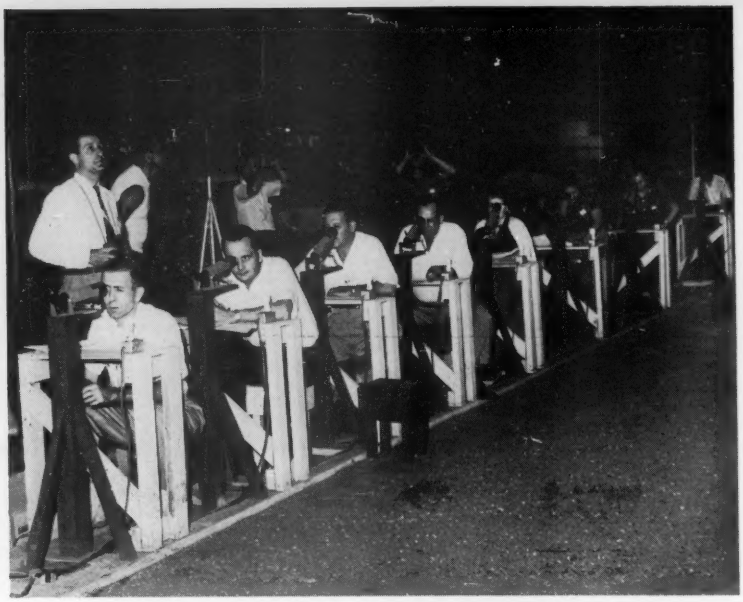

Fig. 3. Terre Haute, Indiana, Moonwatch station.

following the basic principles of operation and equipment utilized in the U.S. IGY program. Our program is under the immediate supervision of Leon Campbell, Jr., while Armand Spitz has been responsible for much of the organization.

More than 3000 observations of the various artificial satellites had been made by 179 of these volunteer Moonwatch stations by 1 April 1958. The program has thus become much more extensive and even more vital to the satellite tracking program than was originally expected. Planned as a program to "back up" the radio satellite tracking program in case of radio failure and as a system for observing the later stages of satellites as they finally plummet through the atmosphere, Moonwatch became the primary network for tracking the huge rocket stages of the U.S.S.R. satellites after the batteries of the radios were exhausted. The high inclinations of these satellite orbits reduced the observational opportunities for the photographic tracking stations located at lower latitudes, while the early firings of the Russian satellites occurred before the completion of the photographic network.

Photographic Telescopes

Although photographic tracking of the rocket stages of the Russian satellites at distances of only a few hundred miles is relatively simple, photographic telescopes are designed to track 20-inch spheres to a distance of 2000 miles. An extremely powerful optical system (*2*) was designed by James G. Baker and produced by the Perkin-Elmer Corporation. The mechanical system, designed by J. Nunn and constructed by the Boller and Chivens Company, facilitates the following of rapid motions of small satellites from rough prediction data without visual acquisition. Hence, the mounting is triaxial (Fig. 4), so that the camera can be pointed at any direction in the sky and adjusted to follow at any angular velocity up to 2° per second along an arbitrarily chosen great circle. A cycling system makes it possible to

Table 2. Air densities.

Geometric height (km)	Air density (gm/cm³)
120	6.91×10^{-11}
130	3.01×10^{-11}
140	1.49×10^{-11}
150	8.07×10^{-12}
160	4.70×10^{-12}
170	2.89×10^{-12}
180	1.87×10^{-12}
190	1.25×10^{-12}
200	8.63×10^{-13}
210	6.04×10^{-13}
220	4.47×10^{-13}
230	3.32×10^{-13}
240	2.51×10^{-13}
250	1.93×10^{-13}
260	1.51×10^{-13}
270	1.19×10^{-13}
280	9.51×10^{-14}
290	7.68×10^{-14}
300	6.27×10^{-14}
310	5.16×10^{-14}
320	4.29×10^{-14}
330	3.58×10^{-14}
340	3.02×10^{-14}
350	2.55×10^{-14}
360	2.18×10^{-14}
370	1.87×10^{-14}

photograph a moving satellite as a fixed point on a single photographic frame and, for reference, a fraction of a cycle later to photograph the star background without trailing. Time is maintained at each station by a precision crystal clock, built by the Norrman Company. As a rotating shutter periodically occults the trailing star images while the satellite is being photographed, the time of the central occultation is photographed on the film to a readable precision of 0.0001 second and a realistic precision of about 0.001 second, limited by the variations in ionospheric path of the calibrating signals from the time standard WWV of the National Bureau of Standards in Washington, D.C.

Figure 5 shows the first image of Explorer I, 1958α, photographed on 18 March 1958 by Robert Cameron at the satellite tracking station near Johannesburg, Orange Free State, Union of South Africa. The power of the photographic system is indicated by the fact that the satellite, optically a 6-inch cylinder painted white over a length of about 40 inches, was photographed at a distance of some 700 miles when it was moving at a rate of 5 miles per second. Figure 6 is a reproduction of the first photograph of Vanguard 1958β1, the rocket stage, optically equivalent to about a 20-inch perfectly reflecting sphere. This photograph was made on 19 March 1958 by E. Horine and J. Emerson at Organ Pass, New Mexico; they were using a Super-Schmidt meteor camera of the Harvard Meteor Program in New Mexico.

Major Results

The major result obtained to date from the tracking of the first three artificial earth satellites is the determination of atmospheric density at altitudes of from 120 to 204 miles, where air densities are too low for determination by sounding rockets. This result is derived from the rate of orbital shrinkage arising from air drag and indicates air densities at 120 miles some five times greater than was anticipated on the basis of previous information. The results obtained by T. E. Sterne, B. Folkart, and G. F. Schilling (*3*) are presented in Table 2 for an altitude range from 120 to 370 kilometers. At the greater altitudes given in Table 2 the extrapolation based upon the measures from the first two U.S.S.R. satellites has been confirmed by T. E. Sterne (*4*) from observations of Explorer I. The temperatures corresponding to the density measurements depend upon the unknown mean molecular weight of the atmosphere at the altitudes involved but probably will be higher than expected. Near an altitude of 390 kilometers the temperature is 3000°K, to be corrected by the ratio of the actual mean molecular weight of the atmosphere to the assumed value of 29.0 atomic units.

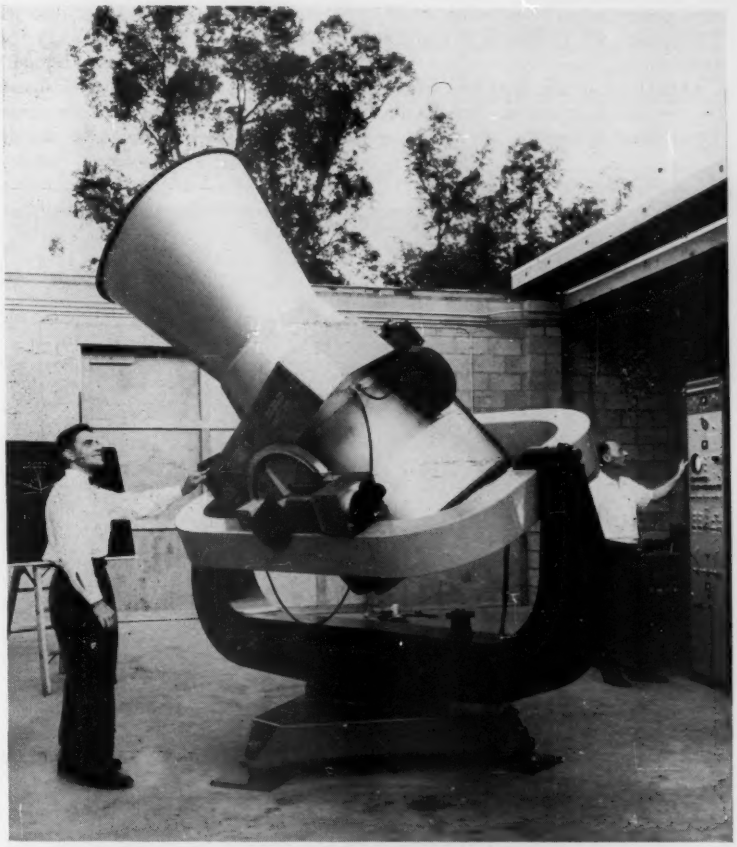

Fig. 4. A Baker-Nunn satellite tracking camera. Karl G. Henize in foreground.

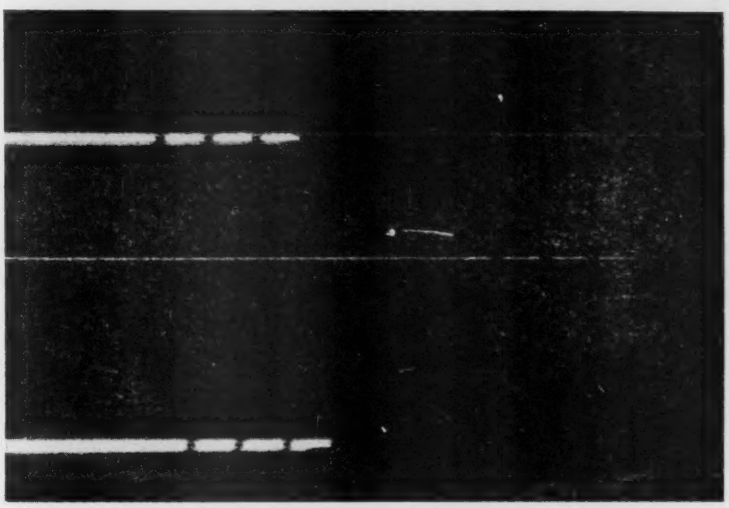

Fig. 5. Photograph of 1958α (Explorer I) taken on 18 March by Robert Cameron at the Olifantsfontein, South Africa, satellite tracking station.

Since the orbital shrinkage by atmospheric drag occurs mostly near the perigee, satellites of greater perigee distance will be required in order to extend these atmospheric density determinations to much greater heights. With its tremendous perigee height of 405 miles, 1958β2 (Vanguard) will lead to an extension of these data.

Orbital calculations have been carried out at the Smithsonian Astrophysical Observatory by the No. 704 calculator of the International Business Machines Corporation (*5*). The orbital planes of the satellites have moved in the expected sense and amount within the degree of accuracy that the analysis to date has permitted. Thus, 1957α and β showed a nodal regression of 3.1° per day and 1958α, of some 4.3° per day. Perigee motions also are consistent with theory. A definitive analysis of the optical data from the two Russian satellites should lead to an improved value for the dynamical oblateness of the earth that produces these perturbations.

The Moonwatch observations during the demise of U.S.S.R. satellites 1957α1 and 1957β1 indicate that as these rocket stages enter the lower atmosphere they glow like meteors for about a revolution before their final disintegration and plunge to the earth's surface. The rocket stage 1957α1 appeared as a very bright object in the late afternoon sky to the Moonwatch team at Los Altos, and over San Diego, California, nearly a revolution before it appeared similarly at two stations in Siberia. Its final breakup was not certainly observed. In the case of 1957β, the rocket was seen after the end of the twilight period by Canadian and New England Moonwatch teams as a fourth-magnitude glowing object. A few minutes later it disrupted in a great meteor-type display over the Barbados Islands, but part of the rocket may have persisted beyond. Thus the heavy satellite rocket stage was in effect a meteor for an appreciable fraction of a revolution around the earth.

A detailed study of these phenomena will be of interest with regard to the interaction between metallic surfaces and the very high atmosphere, both at night and under solar illumination. Of aerodynamic interest is the fact that both rocket stages apparently stopped tumbling and oriented themselves like arrows during their last few revolutions.

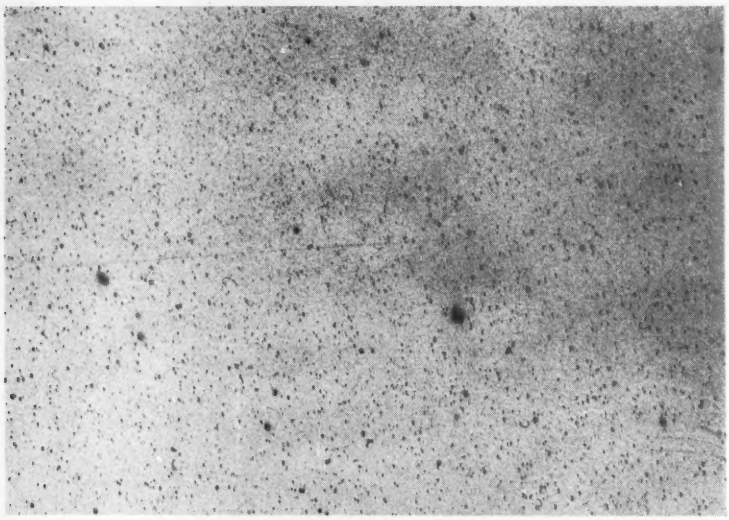

Fig. 6. The first photograph of Satellite 1958β1 (third stage rocket of Vanguard), taken on 19 March by E. Horine and J. Emerson at Organ Pass, New Mexico, with a Harvard Super-Schmidt meteor camera.

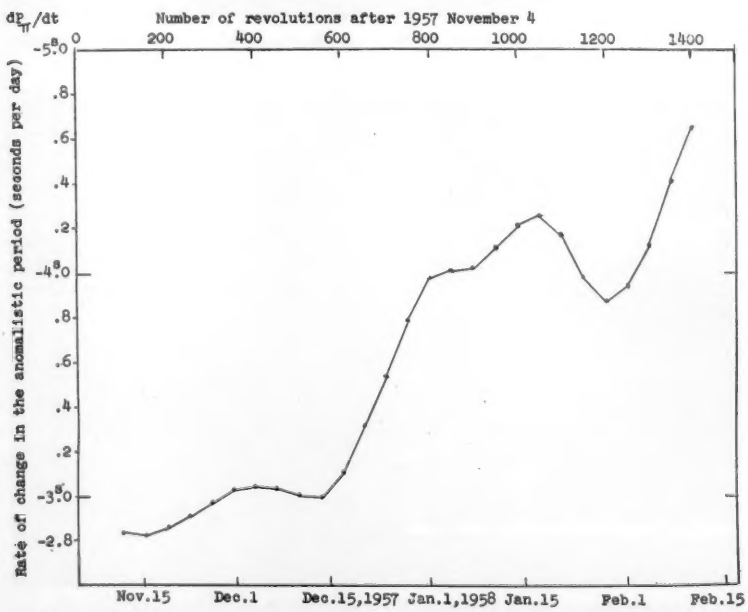

Fig. 7. Rate of change of the anomalistic period as a function of time (1957β1).

Precision Observations

The longer range program with the precision photographic cameras will involve extremely precise tracking and computations in which the satellite is in effect a triangulation target for geodetic measures. The tracking cameras should be able to provide positions accurate to about 2 seconds of arc normal to the trail and 10 feet at 200 miles distance and, along the trail, to an accuracy of 0.001 second or approximately 25 feet. Thus, the geometrical analysis, coupled with the most precise orbital calculations, should lead to determinations of the relative positions of the stations with respect to the center of the earth to an accuracy of some 30 feet, approximately ten times the present available precision. Thus, the geodetic systems of the various continents can be interrelated with this high degree of accuracy, the oblateness of the earth derived to this accuracy, and a more exhaustive search made for lack of circular symmetry around the equator. In addition, the orbital vari-

ations will measure gravitational irregularities, or gravitational anomalies, on the earth and determine more precisely the distribution of matter within the earth. These results will derive from a great many precision observations of satellites for which atmospheric drag can be calculated with assurance—in other words, circular satellites, giving a uniform cross section for atmospheric resistance. Figure 7 shows the variations in the change of orbital period for 1957β1 as derived by L. G. Jacchia (*6*). The elongated object presented a varying frontal area with consequently great irregularities of motion. Predictions for such satellites can be made only a few days in advance, and variations in atmospheric density cannot readily be measured. The rocket stage of 1958β gives great promise of being extremely valuable for these geodetic purposes because of the great perigee distance. Even though the drag itself may not be predictable with precision, its amount is so small that good results are to be expected from precision observations of the rocket stage. The satellite itself, of course, can scarcely be the object of routine observations by any of the available photographic techniques. A more massive satellite, therefore, in an orbit with a very high perigee is the most desirable type for such geodetic investigations, and we expect such satellites to be launched in the near future.

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News of Science

Rockefeller Panel Urges Education Changes

On 22 June the Special Studies Project of the Rockefeller Brothers Fund released a report by its Panel V on "The Pursuit of Excellence: Education and the Future of America." The panel consisted of 15 educators and editors headed by John W. Gardner, president of the Carnegie Corporation of New York. Earlier reports in the Special Studies series have examined military security, economic and social matters, and foreign trade policy.

Following is the report as excerpted in the *New York Times*. The full report has been published as a Doubleday News Book.

I. The Dignity of the Individual

Ultimately the source of a nation's greatness is in the individuals who constitute the living substance of the nation. A concern for the realization of individual potentialities is deeply rooted in our moral heritage, our political philosophy, and the texture of our daily customs.

Our devotion to a free society can only be understood in terms of these values. It is the only form of society that puts at the very top of its agenda the opportunity of the individual to develop his potentialities. But in its deepest sense our concern for human excellence is a reflection of our ideal of the overriding importance of human dignity.

Our success or failure in this task is of crucial importance not for ourselves alone. All over the world peoples are striving for a new and fuller meaning of life. No challenge is more important than to give concrete meaning to the idea of human dignity.

II. The Nature of the Challenge

A. The setting of the problem: our population characteristics. Since 1950 on an average day there has been a net rise of about 7600 in the population; over the year, a rise of some 2,800,000. This may give us a population of not quite 225,000,000 by 1975.

The age composition of the population in 1975 will differ markedly from that of 1955. The recent baby boom will have resulted in an enormous increase in age groups 15 to 24; and as our present middle ages attain the later brackets, there will be a large increase in the age 65 and over.

This pattern of future population will present two vital problems. The first concerns the flood of young people who will place an immense pressure on educational institutions in the next 20 years, and on the labor market shortly thereafter. The second problem involves the social and individual problems posed by a rapidly expanding older group.

B. *The changing demands of society and the pressure on the supply of talent.* One of the striking features of contemporary life is the growing range and complexity of the tasks on which our social organization depends. This is dramatically apparent in science but is no less a reality in nearly every field of endeavor.

The demand for highly trained talent is not a sudden development. It has been coming for a long time. The increase in skill and training needed by our labor force can be expected to accelerate in the years ahead. Automation will reduce the number of routine jobs and will replace them by more demanding tasks of supervision, maintenance and regulation in addition to the production of the machines themselves.

There is a constant pressure by an ever more complex society against the total creative capacity of its people. Our most critical need a decade hence may be unknown today. Rather we must prepare ourselves for a constant and growing demand for talents of all varieties, and must attempt to meet the specific needs of the future by elevating the quality and quantity of talented individuals of all kinds.

One of our great strengths as a people has been our flexibility and adaptability under the successive waves of change that have marked our history. Never have we needed the trait more than today. It is for this reason that we should educate our young people to meet an unknown need rather than to prepare them for needs already identified.

C. The problem of change. One of the characteristics of a dynamic society is that its frontiers are constantly changing. The frontier of today becomes the familiar territory of tomorrow.

A dynamic society requires above all receptivity to change.

D. The social ceilings on individual

performance. A consequence of the complexity and specialization of modern society has been the increasing prominence of organization in our lives. But while complex organization is necessary, it is also costly. It is often a stifling atmosphere for the exercise of individual creativity, and it may induce a conformity that becomes a threat to the society's vitality.

E. Excellence in a democracy. The eighteenth-century philosophers who made equality a central term in our political vocabulary never meant to imply that men are equal in all respects. Nor do Americans today take such a view. It is possible to state in fairly simple terms the views concerning equality which would receive most widespread endorsement in our country today. The fundamental view is that in the final matters of human existence all men are equally worthy of our care and concern. Further, we believe that men should be equal in enjoyment of certain familiar legal, civil and political rights. They should, as the phrase goes, be equal before the law.

But men are unequal in their native capacities and their motivations, and therefore in their attainments. In elaborating our national views of equality, the most widely accepted means of dealing with this problem has been to emphasize equality of opportunity.

The great advantage of the conception of equality of opportunity is that it candidly recognizes differences in endowment and motivation and accepts the certainty of differences in achievement. By allowing free play to these differences it preserves the freedom to excel which counts for so much in terms of individual aspirations, and has produced so much of mankind's greatness.

Every democracy must encourage high individual performance. If it does not then it closes itself off from the mainsprings of its dynamism and talent and imagination, and the traditional democratic invitation to the individual to realize his full potentialities becomes meaningless.

With respect to the pursuit of excellence there are several considerations that we must keep firmly in mind. First, our conception of excellence must embrace many kinds of achievements at many levels. Second, we must not assume that native capacity is the sole ingredient in superior performance. Excellence is a product of ability and motivation and character. Finally, we must recognize that judgments of differences in talent are not judgments of differences in human worth.

III. The Educational System

A. The informal educational system. The formal educational system offers only part of the purposeful education that goes on in a society. Family, church, and school share the fundamental responsibility for education. But in a sense every institution in a society is constantly teaching its members, molding their behavior, contributing to their development: in childhood it may be the scout leader, the playground director, the policeman on the corner; in later years the employer, the union, the mass media.

The most effective educational system can be defeated by a social environment that blunts or destroys aspiration. There can be no striving for excellence without models to inspire emulation.

B. The formal educational system. Our schools are overcrowded, understaffed, and ill-equipped. In the fall of 1957, the shortage of public school classrooms stood at 142,000. There were 1,943,000 pupils in excess of "normal" classroom capacity. These pressures will become more severe in the years ahead. Elementary school enrollments will rise from some 22,000,000 today to about 34,000,000 by 1960–1961. By 1969 high schools will be deluged with 50 to 70 percent more students than they can now accommodate; by 1975, our colleges and universities will face at least a doubling and in some cases a tripling of present enrollments.

If we are to meet these pressures, our schools will need greatly increased public support and attention, and much more money. But they also need something besides money: an unsparing reexamination of current practices, patterns of organization, and objectives.

From time to time one still hears arguments over quantity versus quality education. Behind such arguments is the assumption that a society can choose to educate a few people exceedingly well or to educate a great number of people somewhat less well, but that it cannot do both. But a modern society such as ours cannot choose to do one or the other. It has no choice but to do both.

C. The teaching profession. The number of new school teachers needed in the next decade is between one-third and one-half of all the four-year college graduates of every kind in the same period. The danger of a decline in the quality of our corps of teachers is obvious.

The problem of recruitment is inseparable from the preparation required to enter the teaching profession. If the programs for the preparation of teachers are rigid, formalistic and shallow, they will drive away able minds as fast as they are recruited. Unhappily, preparation for pre-college teaching has come all too close to that condition. In some states the requirements for certification are so technical and trivial as to make it unlikely that individuals with a first-class liberal education would even apply—or be eligible if they did apply.

Fortunately, there appears to be a lively movement to correct these difficulties. As for the preparation of college teachers, the problem is one of reforming and expanding graduate education. There has been more emphasis on research and research training than on the preparation of teachers.

But even with aggressive recruitment there appears to be little or no likelihood that we can bring into teaching at any level anything approaching the number of qualified and gifted teachers we need. We can be certain that there will never be enough teachers with the extraordinary human gifts which make for inspired teaching. We must therefore utilize our superior teachers more effectively.

One way to make better use of the ablest teachers is to eliminate many of the petty tasks which occupy a teacher's time. Less highly trained classroom assistants may accomplish much in the lightening of this burden. Another measure is the employment of such devices as television to bring extraordinarily effective teachers into contact with larger numbers of students than they would otherwise face. Films may be similarly useful.

Such innovations as the teacher aide and television should not be thought of as stopgap measures to surmount the immediate teacher shortage, but of the beginnings of a long overdue revolution in teaching techniques.

But the root problem of the teaching profession remains financial. Salaries must be raised immediately and substantially. Almost as important is the fact that promotional policy for most school systems is routine and depends much more on seniority than on merit.

D. The curriculum. At the pre-college level, the gravest problem today is to reach some agreement on priorities in subject-matter. This problem is particularly critical for those academically talented students who will go on to college. Without presuming to lay down an inflexible set of recommendations, we may suggest what these high-priority items in a solid high school curriculum might be for those of considerable academic ability:

In addition to the general education prescribed for all—four years of English, three to four years of social studies, one year of mathematics and one year of science—the academically talented student should have two to three additional years of science, three additional years of mathematics, and at least three years of a foreign language. For certain students the study of a second foreign language, for at least three years, might replace the fourth year of mathematics and the third year of science.

Particularly with respect to the highest-priority subjects, we must modernize

and improve the quality of the courses themselves.

E. Science education. The crisis in our science education is not an invention of the newspapers, or scientists, or the Pentagon. It is a real crisis.

The U.S.S.R. is not the "cause" of the crisis. The cause of the crisis is our breath-taking movement into a new technological era. The U.S.S.R. has served as a rude stimulus to awaken us to that reality.

The heart of the matter is that we are moving with headlong speed into a new phase in man's long struggle to control his environment, a phase beside which the industrial revolution may appear a modest alteration of human affairs. Nuclear energy, exploration of outer space, revolutionary studies of brain functioning, important new work on the living cell—all point to changes in our lives so startling as to test to the utmost our adaptive capacities. We need quality and we need it in considerable quantity! We must develop guidance efforts designed to reach all able youngsters, and we must engage in a major expansion of the facilities for science teaching.

There is a danger of training scientists so narrowly in their specialties that they are unprepared to shoulder the moral and civic responsibilities which the modern world thrusts upon them. But just as we must insist that every scientist be broadly educated, so we must see to it that every educated person is literate in science.

F. The identification of talent and the uses of diversity. One of the most important goals of any education system is to identify and guide able students and to challenge each student to develop his capacities to the utmost. Tests are most effective in measuring academic aptitude and achievement.

Used with a sound understanding of their strengths and limitations, present testing procedures can contribute significantly to a program of talent identification.

But testing procedures unwisely used can do harm. A few basic considerations must be understood: First, tests are effective on a limited front. Second, no single test should become a basis for important decisions. Third, test scores are one kind of data to be placed alongside other kinds of data.

The identification of talent is no more than the first step. It should be only part of a strong guidance program. As many teachers as possible should be trained to take part in it. As many high schools as possible should have special guidance officers.

The objective of all educational guidance should be to stimulate the individual to make the most of his potentialities. The fact that a substantial fraction of the top quarter of high school graduates fail to go on to college is a startling indictment of our guidance system.

The general academic capacity of students should be at least tentatively identified by the eighth grade as the result of repeated testings and classroom performance in the elementary grades. An adequate guidance system would insure that each student would then be exposed to the sort of program that will develop to the full the gifts which he possesses.

Our schools have made far more progress in identifying different levels of talent than in the development of programs for these different levels. Adequate attention to individual differences means rejecting a rigid policy of promotion by age; and it means sensible experimentation with various kinds of flexibility in the curriculum to meet the varying needs of young people.

A more special problem is presented by the top 2 percent of the high school population. For this group particularly the Advanced Placement Program is important. Under this, an expanding number of secondary schools, both public and private, are offering college-level courses to their best juniors and seniors. Many colleges are prepared to permit such students to "leapfrog" freshman college courses and get credit for them. Another approach is represented by the experimental Program for Early Admission to College, under which about 1000 able students have entered twelve different colleges over the last five years before completing the last year or two of high school.

G. Financing. All of the problems of the schools lead us back sooner or later to one basic problem—financing. It is a problem with which we cannot afford to cope half-heartedly. An educational system grudgingly and tardily patched to meet the needs of the moment will be perpetually out of date.

It is likely that ten years hence our schools and colleges will require at least double their present level of financial support.

It is the weakness in the state and local taxing systems more than anything else that gives rise to current proposals for increased federal support of education. For those who wish to resist or postpone the resort to federal funds and at the same time not constrict educational services there seems to be only one alternative: a thorough, painful, politically courageous overhaul of state and local tax systems.

Federal programs in education now exist on a large scale. It is certain that they will increase both in scale and in variety. There are educational problems gravely affecting the national interest which may be soluble only through federal action.

It would be well to bear in mind four principles in appraising proposals for federal support of education: (i) The Federal Government should address itself to those needs which educational leaders have identified as having a high priority. (ii) Federal funds should constitute one source of support among many. State, local and private sources of funds should continue to be the major factor in the support of education. (iii) It should preserve local leadership and local control over education. (iv) It should be based on a recognition that the Government inevitably exercises a certain leadership function in whatever it does.

Perhaps the most popular form of federal support for education is the scholarship program. Scholarships involve a minimum hazard of federal interference. As long as very few institutions charge tuition covering the full cost of education, a scholarship program which enables the student to pay his tuition should provide the college with a supplementary grant to make up the full cost of his education.

To the extent that the Federal Government can assist in building construction, either through loans or outright grants, it will be engaging in one of the most helpful and least hazardous forms of support to education.

The share of privately financed colleges and universities of total enrollments has already declined to well below 50 percent; and within fifteen years their share of students could easily be closer to 25 percent.

Unquestionably the solution for the privately financed institutions lies not in any one device but in the simultaneous exploration of numerous paths—both for cutting costs and for raising money: for example, eliminating unnecessary frills in the curriculum; sharing facilities with neighboring institutions; dropping the extravagant notion that every institution must offer a carbon copy of the curriculum offered by every other institution; making radically better use of physical facilities; raising tuition; cultivating increased corporate and alumni giving; and obtaining certain kinds of federal support.

Unless changes such as these are carried out there is real danger that the influence of private higher education will progressively decline.

IV. The Use and Misuse of Human Abilities

A. The inadequate use of talent. 1) *The fuller use of underprivileged minorities.* Primary among these groups, is, of course, the Negro, who has been disadvantaged economically as well as politically and socially in the United States. The end of segregation, with all the difficult adjustments it imposes, is of course a step in the right direction. Legislation such as fair employment practices acts will add a necessary stimulus to private

reorientation of attitudes. Until the Negro has been offered equal opportunity with the non-Negro to develop and use his individual talents to the utmost, and until he can be encouraged to make the most of his opportunity, we shall have failed to achieve our moral goal.

2) *Better use of the talents of women.* One out of every three workers in our regular labor force of nearly 70,000,000 is a woman. To this already large contribution, we can expect a substantial increase over the next decades due to the age composition of our population. There are still relatively few professional fields beyond nursing and teaching in which women participate extensively. Many firms still hesitate to use women in executive capacities or to include in executive training programs even those women who expect to remain in employment.

3) *The rehabilitation of economically depressed areas and segments of the population.* The nation is paying a high price for its depressed areas in terms of the wastage of human abilities.

4.) *Better use of older workers.* Only for a portion of older people has retirement with economic security become a treasured period of leisure when one can do "what one always wanted to." For others it is a dreaded break in the texture and tempo of life, leading to personal dissatisfaction on the one hand, and to wasted ability on the other. Remedial action might take the form of a later retirement age. Or it might involve the development of special job opportunities for people over 65. Such opportunities have already been provided in college teaching: the professor retiring from one campus may be hired on special status by some other college.

B. The use of talent in large organizations. Every corporation, union, government agency, military service and professional group should—in its own best interest as well as that of its personnel—conduct a never-ending search for talent within its own staff.

Sometimes a change of jobs is extremely useful in lifting the individual out of his rut and exposing him to new challenges. In this connection it must be noted that nontransferable pension and benefit plans weaken the incentives of men and women to move to positions where better use could be made of their capacities and experience. There seems to be a need for more vesting of pension rights, so that the employee who moves to another job need not leave behind years of accumulated benefits.

Improved opportunities for further education within employing organizations and under community auspices can help mature people to test their own unexplored interests and abilities and to develop their potentialities more fully.

One consequence of the scarcity of professional skills is the hoarding of talent—a practice visible in a good many areas of government, business and academic life.

V. Motivation and Values

Some of our more discerning critics are uneasy about the current aspirations and values of Americans. They sense a lack of purpose in Americans; they see evidence that security, conformity, and comfort are the idols of the day; and they fear that our young people have lost youth's immemorial fondness for adventure, far horizons and the challenge of the unpredictable.

Fortunately we do not need to decide whether the situation is seriously deplorable or only mildly so. The truth is that never in our history have we been in a better position to commit ourselves wholeheartedly to the pursuit of excellence in every phase of our national life. Intellectual and moral excellence has come to play a uniquely important role. It is essential that we enable young people to see themselves as participants in one of the most exciting eras in history and to have a sense of purpose in relation to it.

Still another challenge is that of providing "models" for young people. The life goals of young people are in considerable measure determined by the fact that they identify themselves with admired figures in the adult world.

If we ask what our society invites in the way of high performance we are led to the conclusion that we may have, to a startling degree, lost the gift for demanding high performance of ourselves. It is a point worth exploring.

What most people, young or old, want is not merely security or comfort or luxury—although they are glad enough to have these. They want meaning in their lives. If their era and their culture and their leaders do not or cannot offer them great meanings, great objectives, great convictions, then they will settle for shallow and trivial meanings. People who live aimlessly, who allow the search for meaning in their lives to be satisfied by shoddy and meretricious experiences have simply not been stirred by any alternative meanings—religious meanings, ethical values, ideals of social and civic responsibility, high standards of self-realization.

This is a deficiency for which we all bear a responsibility. It is a failure of home, church, school, government—a failure of all of us.

No inspired and inspiring education can go forward without powerful undergirding by the deepest values of our society. The students are there in the first place because generations of Americans have been profoundly committed to a republican form of government and to equality of opportunity. They benefit by a tradition of intellectual freedom because generations of ardent and stubborn men and women nourished that tradition in Western civilization. Their education is based upon the notion of the dignity and worth of the individual because those values are rooted in our religious and philosophical heritage.

We would not wish to impose upon students a rigidly defined set of values. Each student is free to vary the nature of his commitment. But their freedom must be understood in its true light. We believe that the individual should be free and morally responsible: the two are inseparable. The fact that we tolerate differing values must not be confused with moral neutrality. Such tolerance must be built upon a base of moral commitment; otherwise it degenerates into a flaccid indifference, purged of all belief and devotion.

In short, we wish to allow wide latitude in the choice of values but we must assume that education is a process that should be infused with meaning and purpose; that everyone will have deeply held beliefs; that every young American will wish to serve the values which have nurtured him and made possible his education and his freedom as an individual.

Members of the Panel

John W. Gardner (chairman), president, Carnegie Corporation of New York; president, Carnegie Foundation for the Advancement of Teaching.

J. Douglas Brown, dean of faculty, Princeton University; former member, Mobilization Program Advisory Committee, Office of Defense Mobilization.

Lowell T. Coggeshall, dean of the Division of Biological Sciences, University of Chicago; former special assistant for health and medical affairs, Department of Health, Education, and Welfare; president, Association of American Medical Colleges; president, American Cancer Society.

Philip H. Coombs, secretary and director of research, the Fund for the Advancement of Education, Ford Foundation; former executive director, President's Materials Policy Commission; faculty member, Amherst and Williams colleges.

Dana L. Farnsworth, director, university health services, Harvard University and Radcliffe College; president, Group for the Advancement of Psychiatry; physician, Massachusetts General Hospital.

Eli Ginzberg, professor of economics, Columbia University; director, Conservation of Human Resources, and director of staff studies, National Manpower Council.

Caryl P. Haskins, president, Carnegie Institution of Washington.

Theodore M. Hesburgh, president, University of Notre Dame; commis-

sioner, Civil Rights Commission; member, National Science Board.

Margaret Hickey, public affairs editor, *The Ladies' Home Journal.*

David Reisman, professor, sociology department, University of Chicago.

J. E. Wallace Sterling, president, Stanford University.

Howard E. Wilson, dean, School of Education, University of California, Los Angeles.

Dael Wolfle, executive officer, American Association for the Advancement of Science; former director of the Commission on Human Resources and Advanced Training.

Fred M. Hechinger, associate publisher, The *Bridgeport Herald*; education editor, *Parents Magazine.*

James R. Killian, Jr., president, Massachusetts Institute of Technology; Special Assistant to the President.

New RCA Electronic "Eye"

An extremely sensitive electronic "eye" which may disclose previously unseen details of the planets and distant nebulae, permit visual reconnaissance in almost complete darkness, and provide a powerful new tool for scientific research, has been developed by scientists of the Radio Corporation of America.

The new device is a developmental, advanced type of camera tube, based on television principles and known as the Intensifier Orthicon. In contrast to the conventional Image Orthicon, which is used in present television pick-up functions, the new tube employs either one or two "intensifier" stages between the light-sensitive pickup surface at the front of the tube and the signal output assembly at the rear. The tube was developed by George A. Morton and John E. Ruedy at RCA's David Sarnoff Research Center, Princeton, N.J., in a research program sponsored by the Aeronautical Research Laboratory at the Wright Air Development Center.

According to Morton, the new Intensifier Orthicon is probably 100 times more sensitive than the fastest known photographic film for the same exposure time at extremely low levels of light. It can "see" in surroundings which appear completely dark to the human eye, achieving a sensitivity that approaches the fundamental limit set by photon statistics, Morton claims.

Discussing the various possible applications of the new instrument, Morton emphasized its value in astronomy as a viewing system coupled with a telescope to overcome the effects of the earth's atmospheric turbulence in viewing planets and nebulae. He also mentioned its value in the amplification of dim images such as the light traces left by the passage of high-speed subatomic particles in nuclear research.

Radio Telescope in California

The University of California at Berkeley is planning to enter the field of radio astronomy. Plans call for the erection of an 85-foot radio telescope to be built at a site to be selected as soon as possible. Total cost of the project is estimated at about $500,000. The Office of Naval Research will provide $368,000 for the telescope, and the university will provide $150,000 for land and buildings.

Medical Communication

The Institute for Advancement of Medical Communication, a nonprofit organization, was recently formed to develop ways to increase the efficiency of information exchange among medical scientists, medical educators, and practising physicians. The institute plans to devise and test new methods of disseminating medical information and to serve as an information center for medical organizations that request help with communication problems. The work of the institute will be financed by general and research grants both from private foundations and from the Government.

The charter members of the board of directors are Chauncey D. Leake, professor of pharmacology and assistant dean, College of Medicine, Ohio State University; Homer W. Smith, professor of physiology, College of Medicine, New York University; and Irving S. Wright, professor of clinical medicine, Cornell University. Richard H. Orr, assistant editor of the journal *Metabolism* and former medical director of Grune and Stratton, Inc., will serve as executive director. An advisory board is in the process of being selected. The temporary headquarters of the institute are at 37 E. 67 St., New York 21, N.Y.

Training Reactor in Puerto Rico

On 30 June the Atomic Energy Commission signed a letter contract with AMF Atomics for a pool-type nuclear training and research reactor to be built at the commission's Puerto Rico Nuclear Center in Mayaguez. AMF Atomics is a division of American Machine and Foundry Company and is located in Greenwich, Connecticut. The Puerto Rico Nuclear Center was established by the AEC on 2 October 1957 as a part of the Atoms-for-Peace program.

Under the terms of the agreement, AMF Atomics will design, fabricate, install, and test a 1000-kilowatt (heat), forced circulation, pool-type reactor at the center, which is located adjacent to Mayaguez campus of the University of Puerto Rico.

The reactor, scheduled for completion in mid-1960, will contain features permitting future operation at power levels up to 5000 kilowatts with minimum modifications. The reactor, to be designed for use both as a training and a research facility, will include a thermal column with both horizontal and vertical access, six experimental beam holes, and a dry gamma irradiation facility.

The first phase of the construction program will be completed in 1960. Facilities included in the first phase are the reactor, a laboratory and training building, and a greenhouse for agricultural training and research. All of these facilities will be at Mayaguez.

The center has as its goal the development of a comprehensive program for training and research in nuclear science and engineering, and the peaceful application of nuclear energy to medicine, agriculture, and industry. The program will be available to students in all of the American republics. Four sessions of the radioisotopes training course have already been completed, and courses in nuclear science and technology are being offered at the university's campuses at Mayaguez and Rio Piedras. Instruction generally is provided in Spanish. Charles Bonilla is director of the center.

Scientists in the News

GEORGE R. THURMAN has been named director of the Monterey, Calif., engineering laboratory of the guided missile division of the Firestone Tire and Rubber Company. Thurman, who has been manager of the Firestone defense research division in Akron, Ohio, succeeds Captain FRANK W. MacDONALD (U.S. Navy, retired). V. E. LUCAS, who has been assistant manager of the defense research division, succeeds Thurman as manager of that division.

EMERSON W. CONLON, general manager of the Turbomotor Division of the Curtiss-Wright Corporation, has been named director of engineering and scientific research and professor of mechanical engineering at Drexel Institute of Technology.

BETTY M. WATTS, professor of foods and nutrition at the Florida State University, Tallahassee, has been selected by the American Meat Institute Foundation as the recipient of the F. C. Vibrans' Senior Scientist Award for 1958.

WILLIAM M. MERRILL, associate professor of geology at the University of Illinois, has been appointed professor and chairman of the department of geology at Syracuse University, effective 1 September. He succeeds EARL T. APFEL, who retired in June after 15 years as head of the department.

H. O. HENDERSON, for many years head of the dairy husbandry department and now professor of dairy husbandry at West Virginia University, was given the $1000 Teaching Award in Dairy Production of the National Dairy Products Corporation at the 53rd annual meeting of the American Dairy Science Association at North Carolina State College.

FRITS W. WENT, director of the Earhart Plant Laboratory and professor of biology at the California Institute of Technology, has been appointed director of the Missouri Botanical Garden, St. Louis. HUGH CUTLER, who has been acting director of the garden since December 1956, has been appointed executive director.

JAMES N. SPUHLER has been appointed acting chairman of the department of anthropology at the University of Michigan, effective 1 July. He replaces FREDERICK P. THIEME, who becomes assistant to the president of the University of Washington on 1 August.

G. G. HARRIS, of Columbia University's physics department, and HOWARD GREENBERG and AUREL SEIFERT, both of the City College physics department, have formed the Manhattan Physical Research Group, Inc., located at 556 W. 191 St., New York.

Winners of awards for the five best essays on gravity have been announced by the Gravity Research Foundation, New Boston, N.H. The first award of $1000 was given jointly to GUISEPPE COCCONI and EDWIN SALPETER, professors of physics and nuclear studies at Cornell University, for their paper on "A Search for Anisotropy of Inertia." The second award of $300 was given to QUENTIN A. KERNS of the University of California Radiation Laboratory, Berkeley, for his essay, "A Proposed Laboratory Measurement of the Velocity of Propagation of Gravity."

The remaining awards were made as follows: third award of $200 to JOSEPH WEBER, University of Maryland; fourth award of $150, to WINSTON H. BOSTICK, physics department, Stevens Institute of Technology; and fifth award of $100, to FRITZ ZWICKY, Mount Wilson and Palomar Observatories, Carnegie Institution of Washington, California Institute of Technology, Pasadena.

LYELL F. THOMPSON has been named leader of the University of Arkansas soil testing project. He replaces R. L. BEACHER, who resigned last December to take a position as field representative with the American Plant Food Institute. As associate professor of agronomy, Thompson will be in charge of activities of the Soil Testing and Research Laboratory of the Arkansas Agricultural Experiment Station, including the Eastern Arkansas Branch Laboratory at Marianna. In addition, he will teach courses in soils at the university.

HAROLD K. WILSON, former director of the Division of Intermediate Registration at Pennsylvania State University, has been named the university's associate dean for research and development. He also is a professor of agronomy.

JAMES A. HALSTED, director of Professional Services, Syracuse Veterans Administration Hospital, and associate professor of medicine, State University of New York Medical Center in Syracuse, will be visiting professor of medical science at the University of Shiraz, Iran, for the academic year 1958–59. Halsted will return to his present position in June 1959.

For the first time since 1953 the American Heart Association has made awards in its highest category: Career Investigator. This provides lifetime support for research workers of outstanding ability. The three men chosen were: DAVID B. SPRINSON, professor of biochemistry at Columbia University; JOHN V. TAGGART, professor of medicine at Columbia University; and LEWIS W. WANNAMAKER, associate professor of pediatrics at the University of Minnesota.

GEORGE ROSEN, Columbia University Faculty of Medicine, will give the first annual Victor Robinson Lecture in History of Medicine at Temple University School of Medicine on 23 September 1958. This lectureship, named in honor of VICTOR ROBINSON, professor of history of medicine at Temple University from 1929 until his death in 1947, is appropriately initiated by Rosen, medical historian and personal friend of Robinson.

WILLIAM S. TILLETT was honored on 24 June in the Bellevue Hospital Center when new research laboratories in the department of medicine of New York University's College of Medicine were dedicated in his name. Tillett retired on 1 July as professor and chairman of the department of medicine and as director of the Third Medical (N.Y.U.) Division of the Bellevue Hospital Center. Tillett is now full-time project director for research in the field of allergy and infectious diseases at N.Y.U.–Bellevue Medical Center. A 5-year program began on 1 September 1957 under the auspices of the National Institute of Allergy and Infectious Diseases.

Recent Deaths

CYRUS L. COX, Newark, N.J.; 70; professor emeritus of pharmacy at the Rutgers University College of Pharmacy; former professor of pharmacy at Valparaiso University; expert on emulsions; 23 June.

BERGEN DAVIS, New York, N.Y.; 89; professor emeritus of physics at Columbia University; advanced the study of the excitation and ionization of gaseous atoms by electron impact; invented a double-crystal spectrometer; 30 June.

DONALD A. FLANDERS, Chicago, Ill.; 57; director of the Applied Mathematics Division at Argonne National Laboratory; professor of mathematics at New York University from 1929 to 1948; head of the computing section of the Theoretical Physics Division at the AEC installation at Los Alamos, N.M., from 1943 to 1946; 27 June.

HARRY N. HOLMES, Oberlin, Ohio; 78; professor emeritus of chemistry at Oberlin College; crystallized vitamin A; introduced the laboratory technique of chromatography into the United States; expert on colloids; president of the American Chemical Society in 1942; 1 July.

HOMER L. STANTZ, Rapid City, S.D.; 82; professor of botany at the University of Arizona and expert on grasses, arid lands, and plant geography; president of the University of Arizona from 1928 to 1936; 23 June.

ANDRIJ ASTAMPAR, Zagreb, Yugoslavia; 69; president of the Yugoslav Academy of Sciences and Arts; ex-president of the Assembly of the World Health Organization; former professor of medicine at the University of California and of public health and social medicine at the University of Zagreb; health expert with the League of Nations; 25 June.

CARL K. STEWART, Teaneck, N.J.; 60; metallurgist at the Curtiss-Wright Corporation; 27 June.

MALCOLM R. THORPE, New Haven, Conn.; 67; geologist and paleontologist; curator of vertebrate paleontology at the Peabody Museum at Yale University; 23 June.

FRANK T. WOODRUFF, New Haven, Conn.; 86; retired vice president of Associated Seed Growers, Inc.; specialist in breeding of vegetables, particularly peas and beans; 25 June.

Book Reviews

The Travels of William Bartram. Naturalist's edition. Francis Harper. Yale University Press, New Haven, 1958. lxii + 727 pp. Illus. + plates. $8.50.

Not since Samuel Eliot Morison followed in the wake of the "Admiral of the Ocean Sea" or Allan Nevins tracked "Fremont, Pathmarker of the West" has there been a painstaking study of an American explorer comparable to Harper's tracing of the travels of William Bartram for the twenty years prior to publication of this volume—a goalpost in natural-history literature. The story of William Bartram's life and travels has been more or less told by Darlington (1849), Coues (1875), Stone (1905), Van Doren (1928), Fagin (1933), Brannon (1939), Earnest (1940), Allen (1951), Cheston (1953), and Herbst (1954), but never before so comprehensively as by Francis Harper in what has been appropriately called the "naturalist's edition" of Bartram's *Travels*. The author built, on the careful studies published in 1942 and 1943, around a plan to reproduce, verbatim and *literatim*, the *Travels* of Puc Puggy (as the Seminoles called Bartram) in such a way that this volume may be used with as much confidence as the original 1791 Philadelphia edition; to interpret the scene day by day; and to place the critical words of the narrative in what amounts to a variorum index worthy of a Shakespearian scholar. This annotated index opens up the text at once to the biologist, anthropologist, geographer, or whosoever seeks to know 18th century Florida in its "Eden" days. A field naturalist's affection for the Okefinokee, the Tallapoosa, and the Suwannee and for Bartram's favorite Alachua Savanna is evident on every page of Harper's commentary. The Seminole, wolf, deer, and sand-hill crane that lived on the Savanna are gone, and every true naturalist is saddened by that loss. Lesser prizes survive: the toothache tree still grows at the Rigolets, and the splendid *Magnolia macrophylla* (*"M. auriculata"* of Bartram) at its type locality (unless it has been wiped out in the last two decades). Evidence of Harper's careful pursuit of the Bartram trail is his reporting that tabanid flies, which plagued Billy Bartram in Taylor County, Georgia, also proved so annoying to John Lyon, who passed the same spot in July 1803, 28 years later, that Lyon noted it down in his journal. Records from letters of Muhlenberg and many others sharpen the focus on indistinct passages, and Harper has searched out marginalia, association copies, and the like to enrich the glosses. Here is a 20th century "book of distinction" to read and to treasure. I predict that the book will win a publisher's award for its physical format. Best of all, this "naturalist's edition" of a classic is consummately satisfying for the naturalist reader of scholarly tastes.

JOSEPH EWAN
Department of Botany,
Tulane University

Mitotic Poisons and the Cancer Problem. John J. Biesele. Elsevier, New York, 1958. 214 pp. $7.50.

The many screening programs in cancer chemotherapy carried out especially during the last decade involved testing of thousands of compounds. These screening procedures made use of different approaches—studies of transplanted tumors, tissue culture, microorganisms, and so forth. However, all were concerned with the primary target, the cell, and the effect on it of a chemical agent. A large number of such agents was found to affect mitosis, and a considerable body of information has been accumulated with regard to such "mitotic poisons."

Beginning with a discussion of the concept of mitotic poisons and a classification of such agents, this book is concerned with the response of cells to such substances, presented from the biochemical viewpoint as well as from that of traditional cytomorphology. Inhibition of cell division, damage to the spindle and to the chromosomes during the several phases of the mitotic cycle, and the behavior of other cellular components are discussed from the standpoint of the changes produced, the probable mechanisms underlying such aberrations, and the possible meaning of these changes. The deleterious effects on the mechanics of cell growth and proliferation of antimetabolites and the more newly studied therapeutic agents, as well as the classic mitotic poisons, are discussed.

This is an active area, and the writer has collected and critically presented a sizable mass of data in admirably concise and readable form. The substantial bibliography should be of great value to all interested investigators. Of particular usefulness to workers in the cancer field, this book should also appeal to workers in many disciplines who are interested in basic cytology and the phenomena of cellular damage inflicted by chemical agents.

MORRIS BELKIN
National Cancer Institute,
National Institutes of Health

Flora of the British Isles: Illustrations. Part I, *Pteridophyta-Papilionaceae*. A. R. Clapham, T. G. Tutin, E. F. Warburg; drawings by Sybil J. Roles. Cambridge University Press, New York, 1958. 144 pp. $5.

This quarto-size book is a companion volume to the smaller but thicker *Flora of the British Isles* by the same authors and is designed to be used with it in identification. The arrangement of the figures (there is no text) follows that of the *Flora*, as does the nomenclature, except for rare changes that bring the names up to date. Some species not in the *Flora* are illustrated if they have become recognized or established recently, while a few aliens so rare that fresh material could not be got have been omitted.

The drawings have been made in nearly every instance from fresh specimens, and the aim has been to show the appearance of living plants. In general they accomplish this very well. For each species there is shown the habit of the plant as well as details of pubescence, bracts, flowers, seeds, or other critical parts. The figures are labeled with the scientific name, the common name, and the flower color, and a scale of magnification is provided.

Illustrations of this sort are very useful, for the amateur as well as for the expert, in identification, in particular, of introduced or hard-to-identify groups of plants. This flora may be compared with the new Britton and Brown *Illustrated Flora*, by Gleason, and the *Illustrated Flora of the Pacific States*, by Abrams. The illustrations in the three books are of approximately the same quality, those of the later volumes of Abrams being perhaps the best, and there are approximately the same number. In the two American books the illustrations and text

are combined in sets of three and four large volumes, respectively, and the books are therefore scarcely suitable for extensive field use. One wonders, however, whether the portability of a manual is of sufficient importance to warrant separation of the keys and descriptions from the illustrations. There are arguments on both sides, and it may be that in the long view the postponement of publication of the drawings may speed the appearance of a manual by a factor large enough to offset most of the disadvantages of such a procedure.

For this first of an expected four volumes of illustrations for their excellent *Flora* the authors are to be congratulated. It will be of real use to herbaria everywhere which are concerned with problems of general identification.

RICHARD W. HOLM
Natural History Museum,
Stanford University

Applied Optics and Optical Design. A. E. Conrady. Dover, New York, 1957 (unabridged and corrected edition of ed. 1). ix + 518 pp. $2.95.

This celebrated treatment of lens design exerted a great influence on computational methods when it first appeared in England in 1929. Written by a highly individualistic, not to say uncompromising, teacher of his subject, the book makes no concessions by way of popularization. Thus, although the treatment is not especially mathematical, the reading is not easy. Perhaps it is a sign of our scientific times to find this rigorous account of one of the disciplines of physics appearing as a paperback; serious students will welcome its increased availability. They will do well to read it, in order to relive the thinking which led to the design of the famous Holoscopic series of microscope objectives. The publishers assure us about the durability of the binding, which will be essential if its meaty contents are to be thoroughly digested.

F. A. JENKINS
Department of Physics,
University of California, Berkeley

Annual Review of Entomology. vol. 3. Edward A. Steinhaus, Ed. Ray F. Smith, Assoc. Ed. Annual Reviews, Palo Alto, Calif., 1958. vii + 520 pp. $7.

This is the third and latest volume of an annual series, started in 1956, comprising numerous papers in which specialists in the various branches of entomology have prepared, for their colleagues and others, authoritative and scholarly progress reviews of their specialties. The very definite need for a reference work of this particular type was long realized by all who had to struggle with the widely scattered literature of entomology. Until the establishment of this series, nothing comparable to it existed anywhere.

It was in 1953 that a committee of the Entomological Society of America was appointed to examine the problem of providing adequate reviews of the literature. After exhaustive search and study, the committee recommended that such needs would best be met by a review publication of the general type published by the nonprofit organization, Annual Reviews, Inc. After appropriate investigations and appraisals, the work was started cooperatively between Annual Reviews and the Entomological Society of America. The objective has been the publication of authoritative, concise treatments of subjects of current interest. It is expected that the more active fields of research will require critical reviews annually, while less active fields will be summarized and evaluated as developments require. It is certain that this latest volume will be given the same warm welcome accorded those previously issued, because it possesses the same outstanding usefulness. It is a privilege to commend the 23 papers which make up this volume to the attention of fellow workers everywhere.

J. S. WADE
U.S. Department of Agriculture,
Washington, D.C.

Host-Parasite Relationships in Living Cells. A symposium. Sponsored by the James W. McLaughlin Fellowship Program, University of Texas, Medical Branch, 27 Apr. 1956. Harriet M. Felton, Ed. Thomas, Springfield, Ill., 1957. xix + 245 pp. Illus. $6.50.

This symposium, held in April 1956, was a fruitful commingling of scholars from various disciplines, all concerned largely with biological events within the cell and aware of the urgent need to span the gaps between various disciplines that are focused primarily on the same objective. Contributors to the symposium were E. W. Dempsey, R. J. Dubos, R. Dulbecco, C. E. Georgi, R. A. Good, J. H. Hanks, S. Mudd, C. M. Pomerat, M. G. Sevag, and J. T. Syverton. The meeting contributed to the construction of bridges between cytology and microbiology, including both morphologic and physiologic aspects.

The studies presented and discussed included morphologic observations by electron and light microscopy, immune mechanisms active at the cellular level, and metabolic and other factors influencing the resistance of either host cell or parasite to the effects of the other. A generous portion of this book is devoted to a faithful transcription of the stimulating informal discussion that took place.

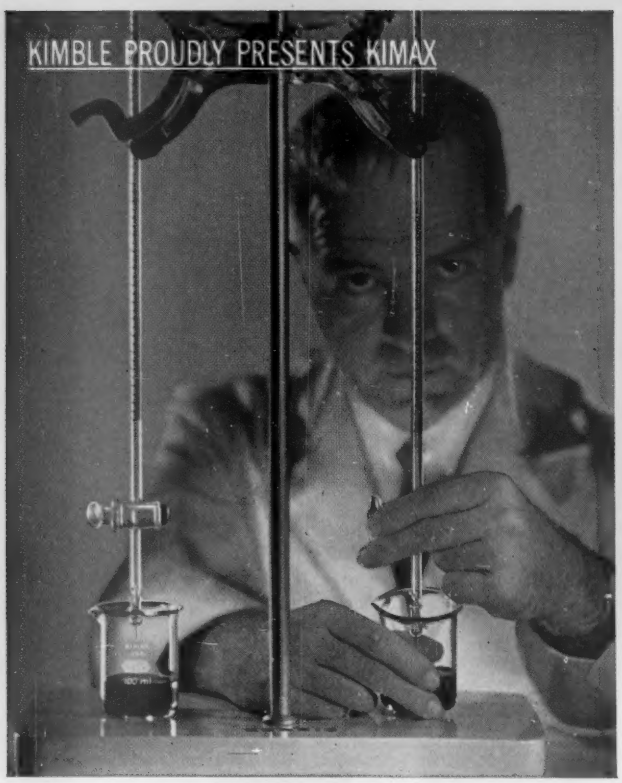
FRANCIS B. GORDON
Naval Medical Research Institute,
National Naval Medical Center,
Bethesda, Maryland

Psychotropic Drugs. S. Garattini and V. Ghetti, Eds. Elsevier, Amsterdam, 1957 (order from Van Nostrand, Princeton, N.J.). 606 pp. Illus. $19.50.

This book consists of papers presented at the International Symposium on Psychotropic Drugs, held in Milan, Italy, in May 1957. Most of them are written in English; others are in German, French, or Italian, with English summaries. These papers reflect the surging interest in biological aspects of normal and abnormal brain function which has resulted from a number of recent events: the discovery that lysergic acid diethylamide, in extremely minute doses, elicits a model psychosis; the discovery that reserpine and chlorpromazine induce effects almost opposite to those of lysergic acid diethylamide; and finally, and most important, the discovery that the biologically active amines, serotonin and norepinephrine, are present in certain parts of the brain. This book, spiced with the diverse viewpoints, hopes, prejudices, disagreements, and naiveties inevitable to a new and emotionally charged area of research, leaves the reader with an appreciation of the urge that provokes investigators to work in "psychopharmacology." This word has been coined to represent the branch of pharmacology which uses drugs affecting behavior to study brain function in the expectation of arriving at an understanding of normal brain function and, ultimately, at the cure or prevention of mental disease.

A number of biochemical papers discuss the possibility that brain norepinephrine and serotonin act as central synaptic transmitters and that certain psychotropic drugs elicit central effects by interaction with these amines. Various views are presented to the effect that mental disease is due to interference with synaptic transmission either by formation of an aberrant metabolite or by the faulty formation, release, or metabolism of a neurohormone. In addition, the effects of psychotropic drugs on a number of enzyme systems involved in brain intermediary metabolism are described.

In the papers on the behavioral effects of psychotropic drugs are described a number of the ingenious methods for studying normal animal behavior and



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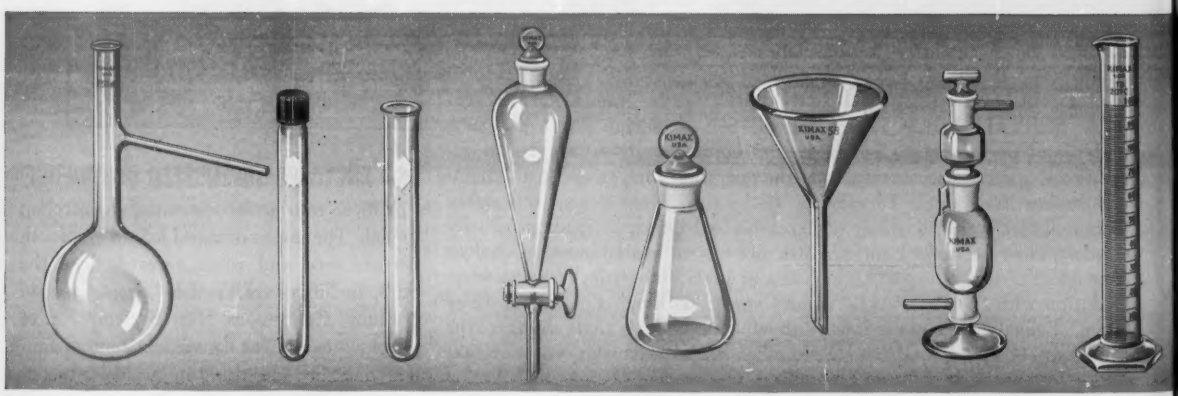

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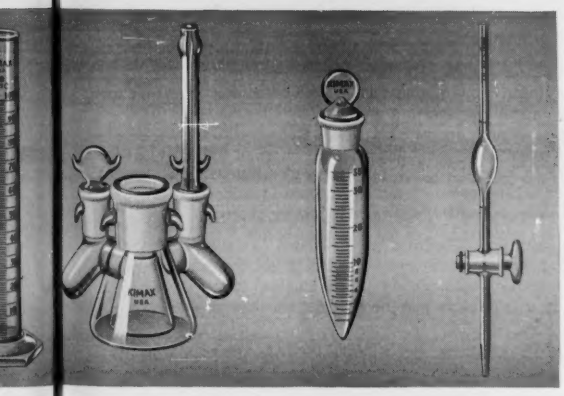

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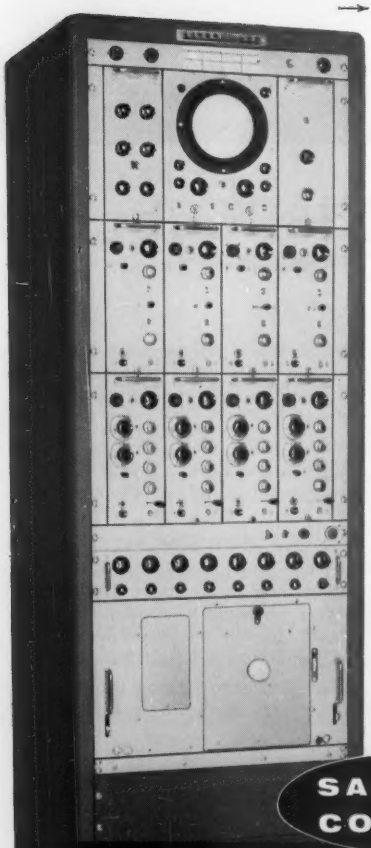

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the effects of drugs thereon. The electrophysiologic presentations are particularly rewarding. These describe the effects of neurohormones and of various types of psychotropic drugs on electrical activities in various parts of the brain and attempt to relate these activities to normal and abnormal behavior.

The pharmacological papers accent the complexity of the pattern of effects elicited by psychotropic drugs. What makes these papers of particular value are attempts to relate pharmacological effects of the drugs to their effects on brain electrical activity and on behavior.

The clinical and psychiatric papers indicate the difficulty of determining the merit of drugs in the treatment of mental illness. Yet they leave the impression that certain of the "tranquilizing" agents are of definite aid in treating the symptoms, though not the basic defects, of mental illness.

BERNARD B. BRODIE
National Heart Institute,
National Institutes of Health

The Bacteriology of Tuberculosis. Egons Darzins. University of Minnesota Press, Minneapolis, 1958. xi + 488 pp. Illus. $10.

The effective treatment of tuberculosis with antimicrobial agents has led to the popular belief that this disease has been conquered. While great strides have been made in decreasing mortality (but probably not morbidity), many unsolved bacteriological problems still remain, and new ones have arisen. The purpose of this book is threefold: (i) to list in historical perspective the advances made toward the understanding of the tubercle bacillus; (ii) to present areas where further knowledge is needed; and (iii) to describe the newer experimental methods for the study of tubercle bacilli.

Basic theories and methods of general microbiology and specific problems pertaining to mycobacteria are described. Tubercle bacilli are discussed under the general headings of "Morphology and cytology," "Sources of energy and growth," "Isolation and identification," "Types and pathogenicity," and "Experimenting." In not all instances, however, are concepts and factual data accurately analyzed and presented. For example, the discussion of L forms of bacteria, on page 71, is misleading, and the tabulation of albumin as a nitrogen source for the metabolism of tubercle bacilli, on page 241, is incorrect. Nevertheless, an extensive subject index and a very comprehensive bibliography provide excellent access to the available literature.

A large section devoted to experimentation with the tubercle bacillus will be of value to the bacteriologist unfamiliar with the special techniques and precautions required in the laboratory.

CYNTHIA H. PIERCE
Rockefeller Institute for
Medical Research

The Principles of Semantics. Stephen Ullmann. Philosophical Library, New York, ed. 2, 1957. 346 pp. $10.

This book is essentially a reprinting of the first edition with a supplement on recent developments in semantics and an expanded bibliography. For Ullmann, semantics is the scientific study of meaning, and meaning is the relation between name and sense, or, as some might prefer to put it, between sign and *designatum*.

Ullmann has described a variety of approaches to questions of change in meaning, semantic laws, homonymy and so on, and in the added chapter he correctly indicates that the most important new problem is that of whether a structural semantics is possible. A meaningful answer must be based on some explicit definitions of the terms *semantics* and *structure*.

A related and, in a sense, logically prior question is whether any semantic notions are essential, or indeed relevant to the syntactics—that is, the purely formal aspects of grammar, consisting of signs and of rules for their combination. If the two are not separable (and this seems to be Ullmann's view), then there is little point in discussing a structural semantics as distinct from a structural syntactics. If they are separable, then whether or not a structural semantics is possible obviously depends on what is meant by structure.

Structural is equated by some with *scientific*. If, as Ullmann suggests, semantics is the scientific study of meaning, then a structural semantics is possible by definition. However, there are some who are not convinced that meaning can be approached scientifically at all. Ullmann asserts that such a discipline exists but nowhere demonstrates that the meaning of a form is anything but an intuitive notion.

One not uncommon use of *structural* is as a synonym for *syntactical*. That is, the rules for the combination of signs are the structure of a language. In accordance with such a usage, structural semantics would seem to be a contradiction in terms.

Some students of language make a dichotomy between the structural elements (by which they mean inflectional endings like the plural *s* and the past tense *ed*) and the *lexical* elements, like *book, run,* and so on. From this point of view a structural semantics would presumably be the study of the meanings of these elements; such a study is not only possible but traditional in many schools of linguistics.

Ullmann quotes some linguists who use *structure* to mean symmetry or patterning and therefore make statements about certain systems or parts of systems being more highly structured than others. This would reduce the problem to the rather trivial question of how much symmetry one can discover (or impose) on the meanings of forms.

Other linguists have mistakenly used *structural* as equivalent to descriptive (as opposed to historical) studies. This is unfortunate, since surely one of the contributions of modern linguistics is to indicate how changes in language may be more clearly understood through a comprehension of the relationships of units to one another at any given time.

Now, if structure is used to express the notion that abstract units are defined in terms of hierarchical relationships to one another, as well as the fact that these relationships recur, then the conscious investigation and systematic description of these features in the area of semantics will be a discipline of increasing interest and importance.

SOL SAPORTA
Department of Spanish,
Indiana University

Toeplitz Forms and Their Applications. Ulf Grenander and Gabor Szego. University of California Press, Berkeley, 1958. vii + 245 pp. $6.

The study of spectral properties of matrices

$$[(C_{i,j})] = [(C_{i-j})],\ C_p = \overline{C}_{-p},\ 1 \leq i, j \leq n,$$

in the limit $n \to \infty$ has received considerable attention in the mathematical literature since the early days of this century.

More recently, analogous studies of integral equations of the form

$$\int_0^T K(x-y)\psi(y)\,dy = \lambda\psi(x),$$

$K(x) = \overline{K}(-x)$, in the limit $T \to \infty$, were also undertaken.

The present volume is an excellent and virtually complete summary of the work done on these and related problems up to 1955.

Toeplitz matrices and translation kernels occur in a wide variety of branches of pure and applied mathematics, ranging from the theory of analytic functions to crystal statistics and the theory of random noise. To present such wealth of material in the limited space of 240 small pages is a feat in itself. To do it

with such skill and elegance should earn the authors the gratitude of all those who might wish to gain acquaintance with this fascinating field.

The book is divided into two parts. The first part (eight chapters), gives the general theory, while the second (three chapters) is devoted to applications.

The latter includes applications to the theory of analytic functions (chapter 9) (centering mainly around the work of Carathéodory, and others, on analytic functions with positive real parts), to the Kolmogoroff-Wiener prediction theory, and to a class of problems related to random walk.

The general theory, which is attributable largely to the senior author, is presented in a unified and self-contained manner.

The chapters on applications complement the general theory, and the book emerges as a harmonious unit.

References and bibliographical notes are collected at the end, and the reader's attention is not distracted by footnotes.

Of course, this is a technical book on a technical subject. But discounting this, and even my own strong prejudices in favor of the subject, I recommend the book as an outstanding example of the power and beauty of analysis.

MARK KAC
Department of Mathematics, Cornell University

Morphological Integration. Everett C. Olson and Robert L. Miller. University of Chicago Press, Chicago, 1958. xv + 317 pp. Illus. $10.

Direct observations of organisms are generally confined to single characters, characters often selected on a basis no more significant than that of expediency. Yet always in systematics and evolution, and often in other biological studies, the integrated whole of the organism is the proper object of concern. That difficulty has been widely recognized, and many biologists have coped with it in numerous different ways and with varying success. Olson and Miller have developed, far beyond anyone else, an approach that involves studying not the characters as such but a relationship among them. Specifically, they analyze, compare, and synthesize figures based on the covariance of multiple dimensions — almost exclusively linear measurements of hard parts of animals.

The dimensions (or measures) used are still defined by expediency, but the failings of expediency are largely neutralized by taking as large a number of different dimensions as is at all practicable. Olson and Miller then calculate correlation coefficients for all pairs of dimensions, taken two by two. In suitable instances partial coefficients are also calculated. The dimensions are then grouped by various and highly elaborated techniques into what the authors call ρ and ρF (that is, correlation and correlation-functional) groups. They have also devised an index reflecting the mean level of correlation among all the variants measured. They thus obtain data for studying the distribution of covariance within animals and among related or phylogenetically successive animals. Intensity and distribution of covariance are, by their special definition, the "morphological integration" of their title.

During the years of preparation of this volume, the authors encountered much misunderstanding and considerable criticism from their colleagues. This volume is especially welcome because it should finally clear away all the misunderstanding about just what they are trying to do, and why. They have also successfully countered most, but perhaps not quite all, of the criticisms. Their work depends heavily—indeed, fundamentally—on evaluation of differences between sample values of statistics, but the confidence levels and significances of these differences are established poorly or not at all. That seems to be the principal remaining methodological weakness.

The amount of work involved is downright appalling. In just one of their experiments, not the most elaborate, the study of a few teeth in a small sample ($N = 18$) of a night monkey involved taking 1494 measurements to 0.01 mm and then calculating 3403 separate correlation coefficients, plus an untold number of partial coefficients, and then performing hundreds, or probably thousands, of grouping operations. The reader is certainly grateful for the more than herculean tasks performed by the authors and their assistants. Yet he can hardly avoid asking, "Was it worth it?" If only the concrete results here published are considered, I must, with real regret, answer, "No." The authors have anticipated the possibility of that reaction. They may (how understandably!) somewhat overvalue the specific outcome, but they have a broader and satisfactory answer of their own. They have demonstrated that their methods do produce information not otherwise available and potentially, at least, pertinent to a considerable range of biological problems.

No systematist or evolutionist can safely ignore this difficult, laborious, brilliantly original, and potentially fruitful monograph.

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Nouveau Traité de Chimie Minérale. vol. III (group 1*a*), *Rubidium, Cesium, Francium*; (group 1*b*), *Généralités, Cuivre, Argent, Or*. Paul Pascal, Ed. Masson, Paris, 1957. xii + 838 pp. Illus. Cloth, F. 6900; paper, F. 6000.

A review of the two previously published volumes, I and X, in this 19-volume treatise on inorganic chemistry appeared in *Science* of 1 Mar. 1957 [**125**, 401 (1957)].

Volume III is devoted to the elements rubidium, cesium, francium, copper, silver, and gold. About 100 pages are given over to rubidium and cesium; 10 to francium; 265 to copper; 220 to silver; and 175 to gold. This volume maintains the high standard set for the series. Inorganic chemists will look forward with interest to the appearance of succeeding volumes.

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Soil–Plant Relationships. C. A. Black. Wiley, New York; Chapman & Hall, London, 1957. vii + 332 pp. Illus. $7.

This book covers the subject matter of a course taught by the author at Iowa State College. The continuing process of adjustment and revision of the material for teaching purposes is reflected in the orderly and concise manner in which the subject matter of the book is presented.

To me, the outstanding characteristic of the book is its accuracy and objectivity. These features will come as no surprise to those soil scientists who are familar with publications of the author's research.

A further noteworthy feature of the book is the intensity of the literature search that has obviously preceded preparation of the manuscript. The author has left few stones unturned in his search for appropriate examples bearing upon the various points discussed. Particular attention has been given to older work. The literature coverage alone is enough to justify the book to many research workers in agriculture.

The book contains chapters on soil composition, soil water, soil aeration, exchangeable bases, soil acidity, soil salinity and alkalinity, nitrogen, phosphorus, and potassium. Some readers will criticize this book not for what it is, but for what it is not. The lack of treatment of the trace elements in a book of this title will be disappointing to research workers in this field. Others may wish for a discussion of ion-exchange equations, or for a special treatment of the process of ion accumulation by roots.

I tend, instead, to commend the book for what it is and to emphasize the fact that the scope of a book is the prerogative of the author. To those starting a research career in soil science this book points not only where we are and how we got here but also where we should go in the future. Its value to the established soil scientist will be in helping him to see his part of the field in relation to the other parts, and to identify and evaluate alternative directions for future work.

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Reports

Turnover of Young and Old Serum Proteins

Up to now it remains unresolved whether the breakdown of serum protein molecules depends on their age, the oldest protein molecules breaking down first, or whether the protein molecules break down randomly. In experiments in which radioactive tracers are involved, it is assumed inherently that newly formed serum protein molecules and older molecules of the same type are identical and that they are metabolized at the same rate. The validity of this assumption has not yet been proved. The experiments described in this report had the purpose of determining whether newly formed and older rat serum proteins, after injection into young rats, have a similar turnover time or whether the older molecules are broken down at a higher rate (*1*).

A yeast protein hydrolyzate containing S^{35}-amino acids was prepared as previously described (*2*). Four Sprague-Dawley rats, weighing approximately 100 g each, from four separate litters, were injected intraperitoneally with 2.4×10^9 count/min of the amino acid hydrolyzate. Eight hours later the blood was withdrawn from these donor rats by heart puncture. This blood was pooled and allowed to clot, and the serum was removed. We designate the labeled serum proteins in this preparation as "young" proteins. Similarly, four other donor rats from four different litters were injected with 9×10^9 count/min of the amino acid hydrolyzate. One of the rats died after 3.5 days (possibly of radiation sickness). The remaining three rats were bled by heart puncture 93.5 hours after injection. The labeled serum proteins in this pooled preparation are designated as "old" proteins. The bulk of the globulins of the "young" and "old" sera was removed by 50-percent saturation with ammonium sulfate; the albumin fraction was salted out by saturation of the supernatant solution with ammonium sulfate. The precipitate was dissolved in 45 ml of water, brought to *p*H 8, mixed with 18 mg of cysteine, and kept in the cold room for 2 hours. It was then dialyzed against water. Paper electrophoresis showed that 72 percent of this albumin fraction consisted of albumin, and 11, 13, and 4 percent of α-, β-, and γ-globulin, respectively.

The radioactive "young" albumins were injected via the femoral vein into four litters of Sprague-Dawley rats, each litter consisting of seven or eight animals. The dose injected per recipient rat was 0.84 mg (260,000 count/min) in 0.2 ml. Fifteen days later four other litters of recipient rats were injected, each animal receiving 1.1 mg (130,000 count/min) of the "old " serum protein in 0.4 ml. During this period of 15 days, the weight of the second group of animals increased so that the average weight at death was 137 g for the first group and 203 g for the second group of animals.

Rats (one from each litter) were exsanguinated by heart puncture 1, 2, 3, 4, 5 (or 5.8), 8, and 9 days after injection, and their livers were removed. The blood was allowed to clot; the serum was then removed and the bulk of the globulins was salted out by half-saturation with ammonium sulfate. The supernatant albumin fraction was dialyzed against water and subsequently precipitated by trichloroacetic acid (TCA). Protein powders were prepared from the TCA-precipitated serum proteins and from the homogenized liver as described earlier (*3*). They were counted on a gas flow counter that had a thin window.

We present our data in terms of relative specific activity (R.S.A.) which is defined as follows (*3*):

$$\text{R.S.A.} = \frac{\text{count/min in 100 mg protein}}{\text{count/min injected per g body wt.}}$$

The values for relative specific activity of the serum albumin fraction and of the liver protein obtained from the four (in some instances three) recipient rats similarly injected and exsanguinated on the same day were averaged and are presented in Fig. 1. A significantly higher relative specific activity is found in the "old" albumins 24 hours after injection, before complete equilibration with the extravascular fluids. The slower rate of equilibration in these animals may be due to their larger size.

After the first day, the decrease of relative specific activity of old and young proteins was almost linear when plotted on semilogarithmic paper. Straight lines (Fig. 1) were calculated from the values between the second and ninth days by means of the method of least squares. Their slope indicates half-lives of 2.9 days for the "young" and 2.8 days for the "old" rat serum proteins of the albumin fraction. The small difference between these two values is not significant in view of considerable individual variations.

The half-lives calculated from the decay rate of the circulating S^{35}-rat serum albumin fraction are apparent half-lives, since they are the result not only of breakdown of the injected material but also of reutilization of breakdown products, S^{35}-amino acids, for the formation of new plasma proteins (*4*). The reutilization of S^{35}-amino acids is clearly indicated by their incorporation into the liver proteins (Fig. 1). However, the true half-life of the serum proteins is only slightly lower than their apparent half-life (*5*).

In evaluating the breakdown of old and young serum proteins, it must be borne in mind that the "young" albumins are formed within 8 hours after injection of S^{35}-amino acids so that their age cannot be more than 8 hours. If neither breakdown nor reutilization of

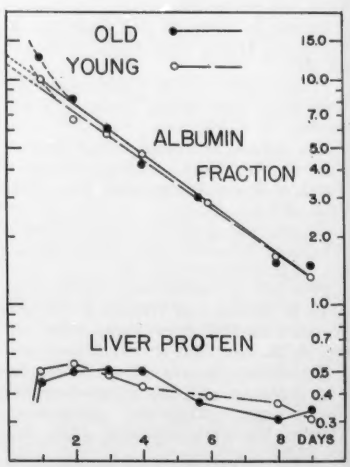

Fig. 1. Relative specific activities of serum albumin fraction and liver protein between the first and ninth days after injection of S^{35}-rat serum protein into rats.

All technical papers are published in this section. Manuscripts should be typed double-spaced and be submitted in duplicate. In length, they should be limited to the equivalent of 1200 words; this includes the space occupied by illustrative or tabular material, references and notes, and the author(s)' name(s) and affiliation(s). Illustrative material should be limited to one table *or* one figure. All explanatory notes, including acknowledgments and authorization for publication, and literature references are to be numbered consecutively, keyed into the text proper, and placed at the end of the article under the heading "References and Notes." For fuller details see "Suggestions to Contributors" in *Science* 125, 16 (4 Jan. 1957).

breakdown products occurred, their average age would be 4 hours. Both processes occur to a small extent, so that the average age is slightly less than 4 hours. The "old" serum proteins are formed within a period of 93.5 hours after injection. Since most of the injected S^{35}-amino acids are incorporated in the first few hours after injection, the average age of the "old" serum proteins at the time of exsanguination is probably between 80 and 90 hours. Although new S^{35}-serum protein is formed later by reutilization of breakdown products, the extent of this process is so small that it can be neglected here.

In spite of the large difference in age between the "young" and "old" proteins, we find no significant difference in their half-lives, nor in their utilization for the formation of liver protein. There is no indication that the age of the molecules has any influence on their rate of breakdown. We conclude, therefore, that the injected serum protein molecules are broken down randomly without any preference for "young" or "old" molecules.

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3 February 1958

Metabolic Reactivation of Rickettsiae by Diphosphopyridine Nucleotide

A previous report from this laboratory (*1*) has shown that *p*-aminobenzoic acid (PABA) forms an adduct with diphosphopyridine nucleotide (DPN+), rendering DPN+ unavailable to DPNase. One implication of these experiments has been applied to link two apparently separated phenomena involving rickettsiae. Fifteen years ago (*2*) it was shown that PABA inhibits rickettsial proliferation, and recently Bovarnick (*3, 4*) has shown "reactivation" of "inactivated" typhus rickettsiae by DPN+. While inconclusive explanations for the PABA inhibition have been offered (*5, 6*), no adequate theory has been presented explaining the "reactivation" role of DPN+, and certainly neither evidence nor hypothesis has ever been proposed relating these widely separated observations. In this preliminary report (*7*) evidence is presented that the PABA-DPN+ adduct (*1*) prevents rickettsial dehydrogenase activity and that such activity is restored when exogenous DPN+ is added to rickettsiae.

Table 1. Effect of PABA on the reduction of DPN+ by rickettsial extracts. PABA, 8 μmole/ml; 3,5-dimethyl-4-aminobenzoic acid, 8 μmole/ml; exogenous DPN+, 8 μmole/ml; L-K-malate, 0.3*M*; buffer, tris, 0.05*M*, *p*H 7.4; *C. burnetii* extract, 1.2 μmole of DPN+ per milliliter; *R. prowazeki* extract, 1.86 μmole/ml; volume made to 3 ml with distilled water; temperature, 35°C. System I was incubated for 16 hr, then system II was added; this mixture was incubated for 2 hr, and then system III added; the final mixture was incubated 45 min; ΔOD was measured at 340 mμ in Beckman B spectrophotometer, and represents final value.

System		1 (ml)	2 (ml)	3 (ml)	4 (ml)	5 (ml)	6 (ml)
I							
	Enzyme	0.3	0.3	0.3	0.3	0.3	0.3
	Buffer	0.5	0.5	0.5	0.5	0.5	0.5
	PABA			0.1			0.1
	3,5-diMe-PABA				0.1		
II	Exogenous DPN+					0.2	0.2
III	Malate		0.5	0.5	0.5	0.5	0.5
ΔOD							
	C. burnetii	0	0.19	0.04	0.19	0.35	0.14
	R. prowazeki	0	0.28	0.03	0.28	0.43	0.23

Purified suspensions of *Coxiella burnetii* (*8*), LD_{50} of 10^{-8}, and the Madrid E strain of *Rickettsia prowazeki*, LD_{50} of 10^{-8} to 10^{-9} (*7*), were separately treated in the Raytheon 9 KC sonic oscillator, and enzyme extracts were prepared. The DPN+ contents of the rickettsial extracts were determined according to the procedure described by Racker (*9*). The cell-free preparation from *Coxiella burnetii* contained 0.36 μmole of DPN+ per 0.3 ml, and the *Rickettsia prowazeki* had 0.56 μmole of DPN+ per 0.3 ml. These amounts were equivalent under the conditions employed to ΔOD's at 340 mμ of 0.17 and 0.205, respectively. The enzymes were treated with PABA, and then reacted with malate, as is shown in Table 1.

The data unequivocally show that, after reaction with PABA, rickettsial DPN+ is not reduced and that such inhibition is partially relieved by the addition of exogenous DPN+ to the system. The addition of 0.8 μmole of PABA to *Coxiella burnetii* produced 79 percent inhibition. When 1.6 μmole of exogenous DPN+ was added, the inhibition was reduced to 60 percent. For Madrid E, under identical conditions, 89 percent PABA inhibition obtained; the inhibition fell to 46 percent upon addition of DPN+. When 0.8 μmole of 3,5-dimethyl-4-aminobenzoic acid was added instead of PABA, no inhibition of dehydrogenase activity was observed. This is in agreement with theory, since the methyl groups on the 3- and 5-positions block the formation of a negatively charged structure at these sites (*1*). These experiments have now been repeated three times, with similar results.

Previous work in these laboratories (*1*) has shown that DPN+ chemically interacts with PABA, forming an adduct. Due to resonance, the unshared pair of electrons of the amino group of the PABA molecule can be shared by the *ortho* and *para* carbon atoms of the ring, and therefore the molecule becomes susceptible to attack by an electrophilic agent such as DPN+. The negatively charged *ortho* carbon of the PABA adds to the positively charged *para* carbon of the pyridinium moiety of DPN+. The evidence presented in this report suggests an explanation for the inhibition of rickettsiae by PABA, based on the above reaction. By forming an adduct with rickettsial DPN+, PABA effectively inhibits cellular reactions involving this vital coenzyme, thus inhibiting rickettsial metabolism. The addition of exogenous DPN+ to such a system relieves inhibition. Other explanations have been previously offered for the rickettsiostatic effect of PABA. Greiff and Pinkerton (*5*) employed PABA on rickettsial-infected embryonated eggs. They proposed that PABA participated in undescribed respiratory mechanisms. In effect, the PABA acted by enhancement of host cell respiration, with resulting deleterious effect on rickettsiae. Snyder and Davis (*6*) demonstrated that the addition of *p*-hydroxybenzoic acid to rickettsiae-infected embryonated eggs relieved PABA inhibition of rickettsiae. They claimed that *p*-hydroxybenzoic acid competitively reverses the action of PABA on rickettsiae. In the work reported in this paper, the inhibitory effect of PABA has been examined in enzyme extracts of purified, nonproliferating rickettsiae. Under such

conditions the complicating reactions of the host cells are removed.

A report is now in preparation describing analogous experiments in our laboratories, in which sulfanilamide was employed instead of PABA. Sulfanilamide is similar to PABA not only in structure but in that similar resonant structures exist in which the positions *ortho* to the amino group possess a formal negative charge. Sulfanilamide inhibitions similar to our already described PABA inhibition have been observed with Gram-positive and Gram-negative bacteria as well as with cell-free preparations of rickettsiae. As in the case of PABA, these inhibitions are relieved by the addition of DPN+. Andrewes *et al.* (*10*) found that *p*-sulphonamidobenzamidine and *p*-sulphonamidobenzamidoxime were potent antirickettsial agents. It is of interest to note that both of these compounds can give rise to resonant structures bearing formal negative charges in the *ortho* positions, which should permit addition to the *para* position of DPN+. Among other things, Andrewes *et al.* (*10*) proposed that nuclear-substituted sulfonamides have "the specific power of adding on to some unknown structure in the enzyme and thus affecting its activity." They further state "it is significant that a free amino group is essential in all drugs derived from sulphanilamide for activity." The latter statement can now be reexamined in light of reference (*1*). Cell permeability has been found in our laboratories to play a significant role in the antibacterial property of sulfanilamide against rickettsial infections.

The evidence presented suggests a simultaneous explanation for both the inhibition of rickettsiae by PABA and the DPN+ reactivation phenomenon of Bovarnick (*4*). Both the Snyder and Bovarnick phenomena seem to have DPN+ involvement as a common factor, the PABA inhibition phenomenon being due to inactivation of rickettsial DPN+ while Bovarnick's reactivation phenomenon restores the DPN+ to rickettsiae in which DPN+ has been eliminated by physical methods. The implications of the data presented, insofar as they offer an additional mode of sulfonamide action, are apparent and emphasize the biological significance of the chemical reactivity of DPN+.

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20 May 1958

Color Reaction of Bilirubin with Sulfuric Acid: a Direct Diazo-Reacting Bilirubin Sulfate

A color reaction of bilirubin with the Liebermann-Burchard reagent was first observed in 1936, but was not reported or studied in detail at that time. It was noted then, however, that following this reaction the bilirubin became soluble in water. Unfortunately the significance of this change in relation to the diazo reaction was not appreciated at that time.

This reaction has now been studied in some detail and has been found to be of special interest because it yields an anionic complex of bilirubin which exhibits a prompt, direct diazo reaction. Except for a brief reference in a recent paper of mine (*1*), no mention of the color reaction has been found in the literature. The reaction occurs more slowly with bilirubin and sulfuric acid alone, and it is evident that the acetic anhydride in the Liebermann-Burchard reagent serves only as a vehicle to bring the sulfuric acid into rapid contact with the bilirubin. The addition of 1 ml of the acetic anhydride-sulfuric acid (10:1) reagent to 5 ml of a chloroform solution of bilirubin is followed promptly by a dark red color, the reaction mixture then exhibiting a strong absorption band at maximum 540 mμ. If the solution is shaken in a separatory funnel with distilled water, the red color at once changes to brown-yellow, and it is evident that much of the pigment has now become water soluble, this fraction entering the aqueous phase.

The remainder of the bilirubin in the chloroform phase may be converted to the water-soluble type by successive addition of small amounts of the Liebermann-Burchard reagent and shaking with water. It is evident that in the course of the reaction small fractions of the bilirubin are converted to a dark brown pigment, probably bilifuscin, which precipitates at the interphase. Biliverdin is also formed in considerable amount, and it continues to form, so that the aqueous, initially yellow or brownish yellow soon becomes greenish brown.

After separation of the pooled aqueous fraction from any entrained chloroform, by filtration, the van den Bergh reaction is prompt and direct in type. Unlike the behavior of starting bilirubin, its behavior is polar, as is shown by reverse phase chromatography on siliconized *kieselguhr*, by the method of Cole and co-workers (*2*). The substance corresponds in chromatographic behavior to their pigment II. The polar pigment is readily separated from biliverdin and other impurities by adsorption on a column of aluminum oxide. The diazo-reacting pigment is held at the top of the column, the impurities coming off with the effluent. The pigment is then readily eluated with 0.1*N* sodium hydroxide solution. It retains its polar character and is not extracted by chloroform upon acidification of the eluate.

Thus far it has been impossible to crystallize this prompt, direct diazo-reacting compound. It is quite labile, readily undergoing oxidation to biliverdin and bilifuscin. Due to its polar behavior and water solubility, it is difficult to transfer to organic solvents, although it is extracted in part by *n*-butanol at *p*H 4 to 5.0. The polar, prompt and direct-reacting pigment is readily diazotized in the initial aqueous solution after the *p*H is adjusted to 4.0. The azo compound is extracted by *n*-butanol and may then be compared with the azo dipyrryl compounds of free bilirubin and of the conjugated bilirubin of human bile, which, according to recent evidence, is mainly an ester diglucuronide (*3–6*). The crude bilirubin glucuronide used in the present study was prepared by Malcolm Campbell (*7*). For the present comparison, Schmid's paper chromatographic method (*3*) was used. The concentrated butanol solutions of the three azo compounds were run on the same strip (Whatman 3 MM), ascending chromatography being achieved with *n*-propionic acid, methyl ethyl ketone, and water (25:75:30). With a solvent front of about 30 cm, the R_f for the azo pigment from crystalline bilirubin is 0.55, that of the glucuronide 0.40. The bilirubin sulfate regularly exhibits two zones, 0.30 (red) and 0.22 (purple). The basis for this has not been determined and is receiving further study.

It has been possible to show that the azo pyrryl compound, after paper chromatography as described, contains sulfate, while that of the glucuronide, under the same conditions, does not. For this demonstration (*8*) a considerable amount of each azo pigment was chromatographed, then eluted from the paper by

ethyl alcohol containing 10 percent HCl (wt./vol.). This solution was concentrated to dryness on a water bath, redissolved in a small amount of 6*N* HCl, and heated at 100°C for 1 hour to hydrolyze the conjugate. The resulting solutions were subjected to the $BaNO_3$ test (*8*) for sulfate ion. This test was consistently positive with the compound believed to be the azo pyrryl sulfate, and negative with the azo pyrryl glucuronide from bile. After hydrolysis of the glucuronide followed by paper chromatography of the reaction mixture and elution with ethanol-HCl (*9*), glucuronic acid was demonstrable by Dische's method (*10*).

Apart from strictly chemical considerations, a bilirubin sulfate is of special interest in the demonstration of another conjugate of bilirubin with an acid radical characterized by a change in the van den Bergh reaction from indirect to prompt direct, of the type observed in the bile and in blood serum from patients with "regurgitation" jaundice. Billing *et al.* (*5*) observed that the conjugated bilirubin from bile is readily converted to free bilirubin in 0.06*N* NaOH at room temperature. They noted, however, that a small fraction was stable to this treatment, behaving as though it were a different type of conjugate. The present bilirubin sulfate is also unaffected by this treatment. Nevertheless, an azo pyrryl compound with R_f corresponding to the sulfate has not thus far been encountered in bile or samples of blood serum, and thus it cannot be stated that the small fraction of alkali-stable, direct-reacting bilirubin observed by Billing is a sulfate. The fact that the bilirubin sulfate is alkali-stable, as compared with the glucuronide, may indicate that the conjugation is through the OH rather than the COOH groups, the latter being conjugated in the glucuronide (*6*).

Despite the failure, at least thus far, to observe the R_f of bilirubin sulfate on paper chromatograms of natural material (bile and blood serum), it is recognized that at least under certain circumstances complexes of bilirubin with acid radicals other than glucuronic acid might be responsible for a prompt, direct diazo reaction (*11*).

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Possible Involvement of Lipids in Protein Synthesis

Since the pioneering observations of Caspersson (*1*) and Brachet (*2*) some 17 years ago on the coincidence of location of ribonucleic acid and protein-synthesizing ability, an impressive number of correlative observations has accumulated (*3*). Because of the sheer weight of this information, one is compelled to recognize that, in general, the maintenance of protein synthesis is dependent upon the integrity and, in some cases, upon the dynamic state of the ribonucleic acid.

The number of papers appearing in the literature pertaining to the possible role of ribonucleic acid in protein synthesis has followed an almost autocatalytic curve, such that in the first decade after the initial observations comparatively little was done or said about the relationship. The emphasis, however, has continued to grow at an increasing rate, so that at present, practically all work in the field includes some observation which is interpreted in terms of the anticipated close relationship. At present ribonucleic acid is given the role of template (*4*), amino acid carrier (*5*), and activator (*4*).

The danger in this trend is in the possibility that it may tend to overshadow and obscure other aspects of the problem of protein synthesis. The fact that microsomal material of a wide variety of cells appears to be the most active component with respect to protein synthesis (amino acid incorporation) and that the major part of the cellular ribonucleic acid is also contained in this structure is often cited in favor of the ribonucleic acid–protein relationship. It is often overlooked, however, that most of the cytoplasmic lipid is also in this structure and, interestingly enough, accounts for about 5 times as much of the total weight as the ribonucleic acid (*6*).

A substantial group of observations supporting a ribonucleic acid–protein relationship is based on the fact that preliminary NaCl extraction or ribonuclease treatment strongly inhibits amino acid incorporation in cells and cell fragments (*3*). It has been similarly observed that in the hen oviduct, purified lecithinase A (*7*), lysolecithin (*7*) and deoxycholate have a very potent inhibitory effect on amino acid incorporation (Table 1).

Coenzyme A and cytosine triphosphate have been shown to be actively involved in the biosynthesis of lipids (*8*). Stimulation of incorporation of amino acids into protein has been observed in the hen oviduct upon the addition of CoA and cytosine triphosphate (*9*). These findings may be the result of a quite indirect relation in the over-all metabolism of the cell, as is also true in most of the observations linking ribonucleic acid to protein synthesis. In experiments reported in this paper (*10*) it has been observed that after a few minutes' incubation the chloroform-soluble lipid fraction of hen oviduct contains relatively large amounts of radioactivity compared with the amount which is entering the proteins or is associated with the nucleic acids. For example, after a 10-minute incubation of a hen oviduct mince with phenylalanine, in which the total cold trichloroacetic acid soluble radioactivity within the cell was 390,000 count/min, the total proteins contained 11,200 count/min, the total nucleic acids (soluble in 5 percent trichloroacetic acid at

Table 1. Effect of lipolytic agents and ribonuclease on phenylalanine-3-C^{14} incorporation in hen oviduct mince.

Conditions for 5-min pretreatment	Medium concentration*	Total count/min incorporated in 10 min	Percentage inhibition†
Control (no additions)		17,200	
Lecithinase A	70 μg/ml	9,000	48
Lysolecithin	210 μg/ml	7,150	59
Deoxycholic acid	0.5%‡	4,600	73
Ribonuclease	210 μg/ml	12,600	34

* These figures are based on the total liquid volume in the incubation and do not indicate the internal concentration of the cells.
† These effects are not due to decreased ability of cells to take up amino acid.
‡ Since the solubility of deoxycholic acid in water is only 0.025 percent, the actual external concentration was much lower.

90°C in 15 minutes and two washes) contained 800 count/min, and the total chloroform-soluble lipids contained 9000 count/min.

The lipid-soluble radioactivity can rapidly enter and leave the lipid fraction and, on the basis of its partition behavior between aqueous and nonaqueous solvents, cannot be in the free amino acid form. Hydrolysis liberates the radioactivity in the form of the administered amino acid (alanine and phenylalanine). Furthermore, the chloroform-soluble lipid fraction contains relatively large amounts of bound amino acids, which upon hydrolysis appear to represent most or all of the common amino acids.

During the past 7 years there have been a number of reports of amino acid and peptide components of lipid fractions (*11*). Since peptides are noticeably absent in the aqueous part of the cell, it is unlikely that they are carried over into the lipid fraction as an artifact. Folch and Lees (*12*) have described a class of proteolipids characterized by their occurring as a white fluff when a solution of a chloroform-methanol extract of tissue is allowed to equilibrate with water. Material having similar characteristics accounts for a major portion of the lipid-soluble radioactivity obtained when hen oviduct is incubated with radioactive amino acid. In the past several years many intensive efforts have been made to find protein precursor material presumably of peptide nature. These efforts have generally met with failure. Since lipid-soluble materials were eliminated in most of these attempts, it would seem worth while to reconsider the possibility that such precursor material may be concentrated in this hitherto ignored fraction.

Several theoretical aspects would make the consideration of a lipid participation in protein synthesis seem worth while. The microsomal membranes present an extensive oriented lipid surface within the cytoplasm. Since it would appear that amino acids may occur in a lipid-soluble complex, it would seem that an efficient means of rapid amino acid accumulation at sites of synthesis may be accomplished by the structure. Furthermore, the energy considerations in the condensation of two amino acids to form a peptide bond with the concomitant splitting out of water would favor a medium of low water concentration.

The present arguments do not in any way detract from the apparent relationship of ribonucleic acid and protein synthesis but are intended to show another possible aspect in the over-all problem.

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20 February 1958

Measurement of the Permeability of the Two Surfaces of a Living Membrane

Recent studies have demonstrated active sodium transport by the isolated toad bladder (*1*). Histologically, toad bladder consists of a single layer of mucosal cells supported on a thin layer of connective tissue containing the blood supply to the tissue and occasional small bundles of smooth muscle. Most of the outer bladder surface has a serosal cover.

When this tissue is mounted as a membrane separating two halves of a Lucite chamber, it can be shown that sodium is actively transported from the solution bathing the mucosal surface to that bathing the serosal surface—that is, in the direction of reabsorption from the bladder urine. Under anaerobic conditions, active sodium transport continues, although at a lesser rate than in the presence of oxygen, and this transport is associated with glycolysis. The lactic acid formed from the glycogen within the membrane does not distribute itself equally about the two surfaces of the membrane, but, regularly, much more accumulates in the medium bathing the serosal surface than in the medium bathing the mucosal surface. This distribution of endogenous lactate is not influenced by the *p*H of the medium on the two sides of the membrane or by the transmembrane electrical potential. This distribution is not dependent on the concommitant transport of sodium ions, for it occurs even when the medium is a choline or magnesium Ringer devoid of sodium. A similar distributon of lactate has been demonstrated about the mucosa of the rat intestine in vitro by Wilson (*2*).

Although more lactate accumulates in the serosal bathing medium than in the mucosal medium, the concentration of lactate is even higher in the tissue water than in the bathing medium. The simplest explanation for the distribution of lactate in the bathing medium is that the mucosal surface is less permeable to lactate than the serosal surface and hence more lactate diffuses out through the latter than through the former.

Figure 1 is a schematic representation of a segment of the bladder wall. The two parallel vertical lines represent the mucosal and serosal surfaces of the membrane, respectively (actually, probably the opposite faces of the mucosal layer of cells); k_1 and k_2 are the respective permeability coefficients of these two surfaces; C_o, C_m, and C_i are the concentrations in mucosal medium, membrane water, and serosal medium of any substance whose permeation is being studied —in this case, lactate.

The generalized equation for the unidirectional flux, M, per unit time for a substance whose concentration on one side is C, across a unit area of membrane containing n separate diffusion barriers is:

$$M = C\frac{k_1 \cdot k_2 \cdot k_3 \cdot \ldots k_n}{(k_1+k_2)(k_2+k_3)\ldots(k_{n-1}+k_n)} \quad (1)$$

The requirement for passive diffusion across any barrier is that the respective value of k be the same in both directions. If any process in the membrane facilitates the movement of the test substance in any manner in one direction across the diffusion barrier, this distinction must be recognized, and the resulting different values of k for the two directions must be used in this equation.

In the case of lactate formed within the membrane, there must exist at least the two diffusion barriers depicted in Fig. 1. The net flux, N, of lactate from mucosal to serosal surface is simply

$$N = (C_o - C_i)\frac{k_1 \cdot k_2}{k_1+k_2} \quad (2)$$

However, there must also exist a transmembrane permeability coefficient, K_{trans}, such that

$$N = (C_o - C_i)K_{trans} \quad (3)$$

Therefore,

$$K_{trans} = \frac{k_1 \cdot k_2}{k_1+k_2} \quad (4)$$

By adding a tracer amount of radioactive C^{14}-labeled lactate to the medium bathing one surface, let us say the mucosal side, and measuring its rate of appearance on the opposite side, K_{trans} can be directly evaluated over successive periods. After several periods during which the constancy of flux rate indicates that a steady state has been achieved, the experiment is terminated, and the membrane is rapidly weighed and ho-

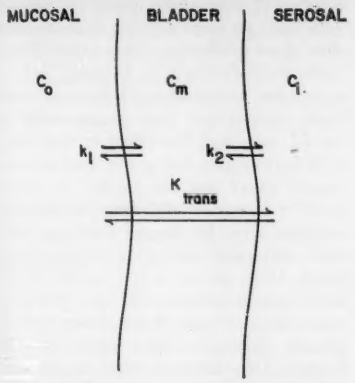

Fig. 1. Schematic representation of a cross section of bladder wall with vertical lines denoting the mucosal and serosal surfaces, respectively.

mogenized in 10 percent trichloroacetic acid to extract the lactate from the tissue. The concentration of C^{14}-labeled lactate in tissue water (*3*) can thus be obtained. From the concentration of C^{14}-labeled lactate within the membrane water and its rate of appearance in the serosal bathing medium, k_2 can likewise be directly evaluated. By substituting values for K_{trans} and k_2 into Eq. 4, k_1 may then be calculated. Because of the relatively low permeability of the membrane to lactate, C_o will remain so much larger than C_i during an experiment that back diffusion may be ignored. The values for k_1 and k_2 may, of course, be evaluated as readily in the opposite direction.

Table 1 shows the values obtained for k_1 and k_2 when measurement was made from mucosal to serosal sides in nine 30-minute periods in three experiments, and from serosal to mucosal surface in twenty 30-minute periods in eight experiments. In every period, k_2 was found to be significantly larger than k_1. Note that any C^{14}-labeled lactate from the medium adherent to the mucosal surface of the bladder will be measured as tissue lactate and tend to make k_2 falsely too low while medium C^{14}-labeled lactate adherent to the serosal surface will result in underestimation of k_1. In spite of this expected limitation in the experimental procedure, satisfactory agreement was found for the values of k_1 and k_2, respectively, when measurement was made in the two directions. This difference in permeability of the two surfaces of the isolated toad bladder is sufficient to account for the observed asymmetrical distribution of lactate about this membrane.

Table 1. Mean values for permeability coefficients for C^{14}-labeled lactate through the isolated toad bladder. All values are means plus or minus the standard error of the mean and are expressed as cm/sec $\times 10^{-7}$. The figures in parentheses give the number of 30 minute periods upon which each value is based.

k_1	k_2	K_{trans}
A. C^{14}-labeled lactate placed on serosal side initially		
5.11 ± 0.59 (22)	94.4 ± 17 (20)	4.62 ± 0.47 (22)
B. C^{14}-labeled lactate placed on mucosal side initially		
4.86 ± 0.67 (9)	$95. \pm 20$ (9)	4.65 ± 0.62 (9)

Since all permeability measurements were made across the short-circuited membrane (*4*)—that is, with no electrical or chemical gradients across the membrane except those of the added radioactive isotopes—the expectation for passive ion movement through the membrane is an equal permeability coefficient as measured in the two directions across the membrane. The mean values and standard errors of the mean shown in Table 1 for lactate for K_{trans} k_1, and k_2 indicate no significant differences in permeability whether the values were obtained during measurements of mucosal to serosal or serosal to mucosal flux. Considering that the measurements in the two opposing directions were of necessity done on different membranes, the agreement is surprisingly good. Thus the passive nature of the lactate movement (simple diffusion) through this membrane is demonstrated.

The permeability coefficients are expressed in centimeters per second instead of square centimeters per second as is customary. This is necessary because the thickness of the diffusion barriers is as yet unknown. We do not know whether the difference between k_1 and k_2 is attributable to a difference in structure of the opposite surfaces of the membrane, to a difference in thickness of diffusion barriers of similar structure, or even to a difference in effective surface area of the two faces of the bladder. This limitation does not affect the relative functional magnitude of k_1 and k_2, which is what has been measured simultaneously in the same membrane.

By analogy with lactate, it is suggested that the main barrier to passive diffusion of sodium is also at the mucosal surface. Such a situation would necessitate that at least part of the active sodium transport mechanism (moving sodium from the mucosal to serosal side) be located on the mucosal surface and function to admit sodium into the mucosal cells at a rate more rapid than can be accounted for by passive diffusion alone (*5*).

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3 February 1958

Ability of Bats to Discriminate Echoes from Louder Noise

The dependence of bats upon echolocation suggests a vulnerability to interference by loud noises. Yet hundreds fly together in the darkness of caves, and artificial jamming sounds have remarkably little effect in the laboratory (*1*). Continuous thermal or "white" noise covering the entire frequency range of the orientation sounds of the long-eared bat *Plecotus* (*Corynorhinus*) *rafinesquii* does increase slightly the figure for minimum detectable size of wire obstacles. This finding permits measurements of the bat's ability to discriminate echoes from noise (*2*).

Across the central part of a 32- by 12- by 8-ft room, 28 vertical wires were arranged in four staggered rows, so that a bat had to fly a zigzag course to dodge the wires at more than the chance level of about 40 percent misses. With the more skillful individual *Plecotus,* the smallest size wire detectable in the quiet was one of diameter between 0.2 and 0.5 mm, well below the wavelengths of the bats' orientation sounds (8 to 14 mm). Thermal noise was generated by two banks of 35 electrostatic loud-speakers, which faced the array of wires from opposite ends of the room. In almost the whole space where wires were detected and dodged, the over-all sound-pressure level was between 80 and 90 db above the standard reference level of 0.0002 dyne/cm^2, and even at the lowest points it exceeded 70 db. The spectrum level of the noise varied no more than ± 5 db from 15 to 55 kcy/sec, but fell off sharply beyond these limits; thus, the noise level per cycle of band width was usually more than 34 db and always exceeded 24 db. Figure 1 includes all data for the five individual *Plecotus* whose flight was most consistent during 5 days when they were at the peak of their flying skill and avoided 1- to 1.5-mm wires in 80 to 100 percent of the flights, in quiet and in noise. In the control tests,

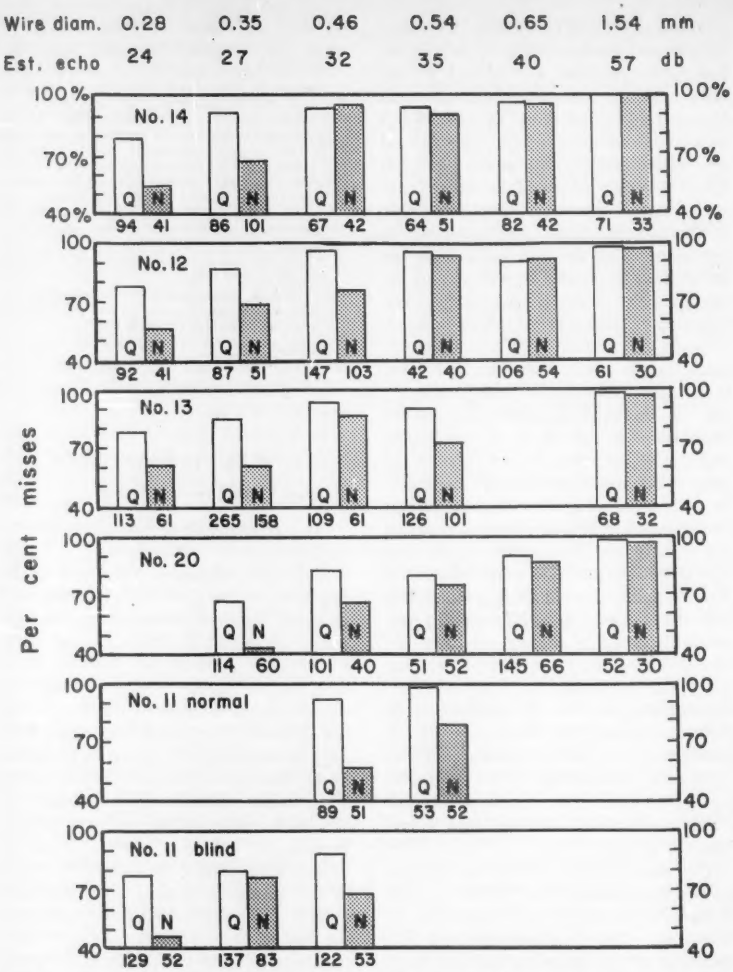

Fig. 1. Obstacle avoidance scores of *Plecotus rafinesquii* flying through an array of vertical wires, in quiet and in thermal noise, as a function of the diameter of the wires. Each bar graph shows the percentage of misses for a single bat during the period when it was at its maximum level of flying skill, for flights in the quiet (Q) and for those in the noise (N). The number of trials in each series is listed below each bar. The estimated echo levels are given in decibels above 0.0002 dyne/cm^2.

consisting of about equal numbers of flights in the quiet before and after introduction of the noise, these bats showed no appreciable deterioration of performance due to fatigue or other factors. All these bats flew skillfully in the noise, landed normally, and were difficult to capture with a net.

In each of the 1- to 2-msec pulses of sound used by these bats, the frequency drops from 40 to 25 kcy/sec—that is, by about 125 cy/sec from one wave to the next. Sound spectrographs showed that throughout each pulse the energy was spread over a band width of at least 5 kcy/sec, or 37 db above 1 cy. A listening system tuned to a single pass band narrower than this would simply exclude part of the signal. Spectrographs of pulses emitted in the noise showed that, at 8 cm from the bat's mouth, the spectrum level of the outgoing sound was within ± 10 db of the level of noise in the same frequency band.

The echo levels included in Fig. 1 were calculated, by methods described elsewhere (*1*), on the assumption that echoes were not heard above the noise until the bat was 10 cm from the wires and that the emitted signal was at the highest level observed in the noise (about 80 db) rather than at the average level (65 db) observed in the quiet. It is unlikely that these bats had learned the position of the wires, because of the large number of wires and because, in the noise, the smaller-size wires were avoided at little better than the chance level, although their positions should have been no more difficult to remember than those of the larger-size wires. If the wires were detected by listening not to echoes but to variations in the noise field itself, interference with sound emission should have had less effect in the noise than in the quiet. But application of ventilated paper muzzles similar to those used by Dijkgraaf (*3*) reduced obstacle avoidance to the chance level in both noise and quiet, with large obstacles and small. Only one or a few pulses could have been emitted while the *Plecotus* were within 10 cm of the wires, and at greater distances echoes would be still fainter. The 0.54-mm wire, which was dodged quite successfully by all five bats, returned echoes of 35 db, or 36 db below the noise in a 5-kcy/sec band, while the 0.35-mm wire, which bat No. 11 dodged rather well after being blinded, provided echoes 43 db below the level of the noise.

It seems conservative to conclude that these bats can hear echoes that are at least 35 db below the level of the noise and that this ability must involve selective recognition of some property of the echoes not shared by the random noise. The pulsed nature of the echoes might be one such property, but thermal noise switched on and off with a 50-percent duty cycle at rates up to 1000 per second was, if anything, less effective in jamming *Plecotus* than continuous noise. The large ears may render the hearing of this species highly directional, but wires were often dodged skillfully when they were directly (within ± 10°) in line with one of the loud-speakers. The frequency sweep within each pulse, or the time relations between emission of a pulse and arrival of echoes from objects at close range, may aid in this impressive auditory discrimination. In any event, a bat brain weighing less than 1 gram contains highly effective data-processing mechanisms which can act upon information contained in one or a few echoes having no more than 1/2000 of the noise energy simultaneously present in the same frequency band.

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12 March 1958

Effects of Methimazole on Thyroid and Live Weights of Cattle

Interest in the potential usage of different goitrogenic agents, especially thiouracil, in livestock and poultry production is manifest in the large number of investigations that have been made during the past 15 years, many of which are cited by Sykes *et al.* (*1*). Most investigators have studied the use of thiouracil in reducing basal metabolic rate in animals for purposes of either stimulating fattening in meat-producing animals or bringing about a more efficient over-all usage of the respective rations fed. Although some success has been achieved with thiouracil in reducing metabolic rate in animals (*2*), nevertheless other, unfavorable features have been noted in connection with its administration, such as its unpalatability and its tendency to slow rates of growth; hence, no general use of goitrogens in animal feeding has thus far been made. The objectives of the investigation described in this report were to determine the amount of a potent synthetic goitrogen, methimazole (1-methyl-2-mercaptoimidazole, or Tapazole) (*3*) necessary to bring about enlargement of the thyroid in cattle and to observe the influences of methimazole upon appetite, live-weight gains, and efficiency of feed utilization when it was fed to growing and fattening beef animals.

Thirty steers, weighing about 975 pounds each, were divided into six groups and full-fed a mixture of corn, hay, and protein supplement containing stilbestrol, a growth-promoting substance for beef cattle reported earlier (*4*). The rations were alike except for the amounts of methimazole added to the respective rations. Groups 1a and 1b received no methimazole, whereas groups 2, 3, 4, and 5 received rations that contained methimazole in the following percentages: 0.0017, 0.0035, 0.0052, and 0.0070, respectively. These levels corresponded to 200, 400, 600, and 800 mg per animal per day. The feeding experiment was carried out during the late fall and early winter season, during which the temperature was below freezing much of the time.

The results are presented in Table 1. Thyroid weights were rather variable within groups, but on the average they increased with each level of methimazole fed, the highest level producing thyroids approximately four times the size of those in the control cattle. The increased weights of the thyroids of the cattle in this study suggest that the levels of methimazole fed were sufficiently high to inhibit thyroxin secretion. The improvement noted in over-all feed utilization might be explained on the basis of a lowered thyroxin secretion and thus a lowered metabolic rate, whereby a higher percentage of the ration was converted into cattle live-weight gains. Live-weight gains were excellent in the cattle receiving methimazole, and in all cases these gains exceeded the gains made by the control animals. The maximum stimulation in gain by lots was 22 percent, and the average stimulation amounted to 11 percent. No depression in appetite accompanied the feeding of methimazole; rather, the cattle receiving the goitrogen consumed an average of 3 percent more feed than the control cattle. Over-all feed utilization was increased by the methimazole as much as 13 percent, with an average increase of 7 percent. The quality of meat produced by the inclusion of methimazole in the ration was indistinguishable from the quality of meat of the control cattle on the basis of federal grades and dressing percentages.

It was interesting to note that methimazole did not depress appetite, whereas thiouracil usually inhibits appetite and results in lowered rates of growth in almost all species of animals. This apparent discrepancy in the action of these two goitrogens is believed to be due to the unpalatableness of the thiouracil or to its greater toxicity at equivalent dosage levels. In earlier cattle experiments in this laboratory (*5*) it was impossible to feed sufficiently high levels of thiouracil to depress thyroid activity appreciably without at the same time decreasing feed consumption and rate of live-weight gain.

Table 1. Results of adding methimazole to the ration of cattle in a 79-day experiment.

Item	Methimazole added				
	Lot 1 None	Lot 2 0.0017%	Lot 3 0.0035%	Lot 4 0.0052%	Lot 5 0.0070%
Av. initial wt. of cattle (lb)	976	977	981	976	985
Av. final wt. of cattle (lb)	1209	1245	1226	1258	1222
Av. daily gain (lb)	3.0 ± 0.1*	3.4 ± 0.2	3.1 ± 0.1	3.6 ± 0.1	3.1 ± 0.2
Av. daily ration					
Cracked corn (lb)	17.7	19.1	18.1	19.0	18.0
Alfalfa hay (lb)	6.0	6.0	6.0	6.0	6.0
Supplement (lb)	1.0	1.0	1.0	1.0	1.0
Total (lb)	24.7	26.1	25.1	26.0	25.0
Feed/100-lb gain (lb)	837	770	804	726	831
Dressing percentage	59.8	58.1	59.5	59.5	60.0
Federal carcass grade					
Choice	4	3	2	1	2
Good	6	2	3	4	3
Av. wt. of cattle thyroid (g)	29 ± 3	35 ± 5	65 ± 10	70 ± 8	123 ± 18

* Standard error of mean.

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References and Notes

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2. H. Singh and C. S. Shaffner, *Poultry Sci.* 29, 575 (1950).
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5. W. Burroughs *et al.*, *Iowa Agr. Expt. Sta. Animal Husbandry Leaflet No. 218* (1957), p. 1; A. Raun, E. Cheng, W. Burroughs, *J. Animal Sci.* 16, 1062 (1957).

14 February 1958

Electron Microscopy of the Anaplasma Body: Ultrathin Sections of Bovine Erythrocytes

Anaplasmosis is an infectious disease of cattle. However, it has been recognized in another species (ovine) on one occasion in the United States (*1*). The acute or peracute form of the disease is

seen in adult cattle and frequently terminates fatally. Symptoms of the disease are elevated body temperature, anemia, anorexia, atony of the rumen, accelerated respiration and pulse, pale mucous membranes, constipation, depression, icterus, and weakness, and abortions often occur in advanced pregnancies. During the febrile period as many as 77 percent of the circulating erythrocytes contain bodies referred to as anaplasma bodies. Young calves develop a mild form of anaplasmosis; however, a splenectomized calf will develop acute or peracute anaplasmosis. Cattle which have recovered from anaplasmosis are immune to the disease but are permanent carriers. Minute amounts of blood from such cattle will reproduce anaplasmosis when injected into a susceptible bovine.

The etiology of the disease has not been established, but it is generally assumed that the anaplasma body is the etiologic agent of anaplasmosis. This body is generally considered to be a protozoan and is designated *Anaplasma marginale* (*2*). The anaplasma bodies are characteristically located at the periphery of the erythrocyte (Fig. 1 top left) and vary in size from 0.2 to 0.9 μ, the larger ones being composed of eight spherical "sporoid" bodies of equal size (*3*). They are said to be devoid of cytoplasm (*4*). The suggestion has been made that the anaplasma body is constituted of tightly packed submicroscopic elementary bodies and that the parasite undergoes multiple division instead of binary fission (*5*). A previous study by one of us (L.E.F.) demonstrated an ultrafiltrate of blood to be infective, thereby suggesting that the anaplasma body is a viral inclusion (*6*). The results of this investigation are presented to define better the nature of the anaplasma body.

Whole blood was drawn into a dry 10-ml syringe from the external jugular vein of a splenectomized calf affected with anaplasmosis. Seventy-seven percent of the erythrocytes contained anaplasma bodies. The blood was transferred immediately into a fixative composed of 1-percent osmic acid in a Veronal-acetate buffer, buffered to *p*H 7.4 (*7*) and maintained at 5°C. The fixation times used were 5, 10, 15, 20, and 30 minutes. Following fixation, the fixative was decanted from the cells and the cells were washed with distilled water and dehydrated with increasing concentrations of methyl alcohol. The cells were then embedded in a 1:3 mixture of methyl and butyl methacrylate. Sections of the embedded cells were cut on a Porter-Blum ultramicrotome at a thickness of 1/20 to 1/40 micron by means of a glass knife. The sections were mounted on copper grids with a Formvar film and viewed in an RCA EMU 3 electron microscope. Fixation for 20 minutes was found to be optimal.

With the electron microscope the anaplasma body is seen as a clear space at the margin of the erythrocyte, containing from one to seven masses of dense particulate matter (Fig. 1 top right and bottom left). The masses comprising the anaplasma bodies measure from 0.2 to 0.7 μ in diameter. The larger masses are seen in bodies containing single masses, while smaller ones are seen in bodies containing mutliple masses. The dense particulate matter typically consists of a central mass and a peripheral ring separated by a clear zone in which are seen a variable number of strands connecting the central mass and peripheral ring. Figure 1, bottom right, at greater magnification, demonstrates the particulate composition of the anaplasma body. The size of the particles is approximately 100 A. None of the organelles of a cell have been seen in the bodies—such as nucleus, mitochondria, and endoplasmic reticulum.

These observations (*8*) support the idea that the etiologic agent of anaplasmosis is a virus.

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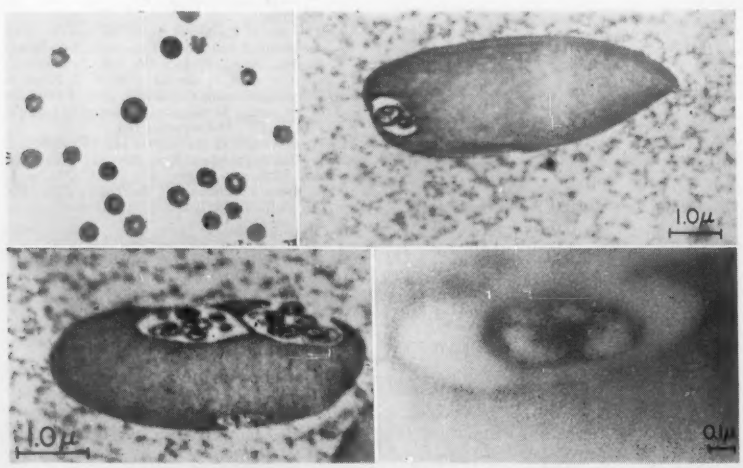

Fig. 1. (Top left) Peripheral blood smear with Giemsa stain (about × 730); (top right) anaplasma body in erythrocyte; (bottom left) anaplasma bodies in erythrocyte; (bottom right) anaplasma body in erythrocyte.

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3 February 1958

Spray Mechanism of the Cockroach Diploptera punctata

The cockroach *Diploptera punctata* (Eschscholtz) has a remarkable pair of glands, the secretion of which contains a mixture of *p*-benzoquinone and two of its derivatives (*1*). Each gland consists of a cluster of secretory cells surrounding a dilation of the trachea leading to the second abdominal spiracle. The secretion is stored within the tracheal dilations and is ejected through the second abdominal spiracles when the roaches are agitated, anesthetized, or otherwise disturbed (*1*).

The very fact that disturbance elicits ejection suggests that this secretory apparatus is defensive in function. This contention was confirmed by a recent series of experiments (*2*), the main results of which are presented below.

The secretion of *Diploptera*, like that of other arthropods that also secrete quinones, imparts an intense bluish-black coloration to acidulated KI-starch paper (*1, 3*). This indicator paper affords a convenient means of recording the direction, range, and degree of dispersion of the secretory discharge. Individual roaches, fastened to fixed rods and adjusted so that they assumed normal stances on sheets of indicator paper,

were subjected to traumatic stimuli as follows: individual appendages were gently pinched with fine forceps or parts of the body were poked with a hot needle. Except for newly molted individuals, all adults and nymphs responded instantly to such stimuli by ejecting a discharge. The inability of newly molted individuals to discharge is undoubtedly due to the fact that at each molt the cuticular wall of the tracheal reservoirs and the quinones within are shed along with the other tracheal linings (*1*). The reservoirs were found to be replenished 8 to 24 hours after molting and the roaches were again able to discharge noticeably.

As evidenced by the pattern on the indicator paper (Figs. 1 and 2), the secretion is ejected in the form of a fine, broadly dispersed spray. Interestingly, both glands rarely discharged simultaneously. Usually, only the gland corresponding to the side of the body subjected to stimulation discharged at any one time (Figs. 1 and 2). A synchronous discharge of both glands occurred only when an appendage was persistently pulled, when appendages of opposite sides were pinched simultaneously, or when a persistent thermal stimulus was applied over a broad surface, as with a spatula. The number of consecutive discharges that could be produced by any one roach varied considerably. In general, up to four discharges could be elicited readily from each gland of large nymphs and adults, provided the roaches had not been disturbed for 2 or 3 days prior to stimulation.

In another series of experiments, aimed at evaluating the repugnatorial effectiveness of the spray, series of roaches were subjected to direct attacks of predators. The predators consisted of carabid beetles (*Galerita janus* Fabr.), praying mantids [*Hierodula patellifera* (Serville)], lycosid spiders (*Lycosa helluo* Walckenaer), and ants [*Pogonomyrmex badius* (Latr.)]. The mantids, spiders, and carabids were released individually into test arenas made of large finger bowls or beakers lined with indicator paper, in each of which they had access to a single *Diploptera*. The experiments with *Pogonomyrmex* were performed directly in front of the nest opening of a thriving laboratory colony of this ant, with the roaches affixed to rods and placed on sheets of indicator paper. All predators attacked readily, and in each case the roaches responded instantly by ejecting the spray. The discharge was usually unilateral, toward the particular appendage or quarter of the body seized by the predator.

The ants and carabids were in all cases repelled promptly by the secretion and retreated before they had inflicted noticeable injury. Conspicuous in the course of their escape was a series of abnormal seizures, during which leg movement became discoordinated and ineffectual, hampering and sometimes halting locomotion. These seizures, altogether, rarely lasted more than 2 minutes, and recovery was always complete. The spiders were also repelled, but only by the larger nymphs and adults; young nymphs were usually eaten promptly. Unlike the carabids and ants, the spiders never showed noticeable abnormalities following the impact of the spray. In a control study, all of the above-mentioned predators were offered freshly molted roaches and others from which the glands had been excised; such individuals proved vulnerable and were always eaten (Fig. 3).

The praying mantids seemed to be completely unaffected by the spray, and every roach seized was invariably devoured. I am told by Susan Rilling, of Tufts University, that some of her mantids have been fed routinely with *Diploptera* for several days at a time, without apparent ill effects.

No extensive experiments with vertebrate predators have been made as yet. Some mice (*Mus musculus* L.), birds [*Cyanocitta cristata* (L.)], and lizards (*Anolis carolinensis* Voigt) were found to eat individuals of *Diploptera* when these were offered to them for the first time. However, before repugnatorial effectiveness of the secretion against vertebrates can be ruled out, it will be necessary to determine whether repeated encounters with this roach might not result in discrimination against it.

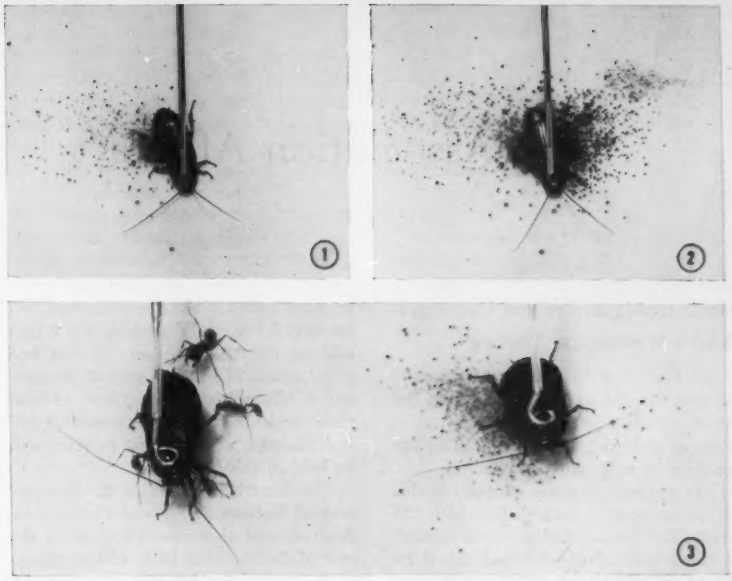

Fig. 1. Spray pattern (on KI-starch indicator paper) of discharge of the right gland of roach, following pinching of the right mesothoracic leg. Fig. 2. Same roach as shown in Fig. 1 after a second discharge but from the left gland, following pinching of the left mesothoracic leg. Fig. 3. Roach on left has had its glands excised and is under persistent attack by several ants (*Pogonomyrmex badius*). The intact roach on right was attacked, but it sprayed and repelled its assailants.

Quinone secretions are known to occur in a wide variety of other arthropods, including tenebrionid and carabid beetles, millipedes, and phalangids (*1*, *3*). Experimental and behavioral studies on many of these are currently being done at our laboratory, and some of this work has already been reported elsewhere (*4*).

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References and Notes

1. L. M. Roth and B. Stay, *J. Insect Physiol.*, in press.
2. This study was aided in part by a grant from the U.S. Public Health Service. I am indebted to Dr. E. A. Chapin, Dr. W. J. Gertsch, and Dr. J. A. G. Rehn for identifying, respectively, the *Galerita*, *Lycosa*, and *Hierodula*. Thanks are due Dr. L. M. Roth for supplying *Diploptera* and to Dr. K. Roeder and Mrs. Susan Rilling for allowing me to use *Hierodula* at their laboratory at Tufts University. Mr. P. A. Adams of Harvard University took the photograph shown in Fig. 3.
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21 February 1958

Association Affairs

Hotel Headquarters and Housing, AAAS Washington Meeting

All the complex arrangements for the seventh Washington meeting of the American Association for the Advancement of Science, 26–31, Dec. 1958, are progressing well and on schedule.

The preliminary announcement of this 125th meeting [*Science* **127**, 1246 (23 May 1958)] was principally an outline of the 300 or more sessions planned by the 18 AAAS sections and some 91 participating organizations. Additional program details have since come in. In a number of instances, symposia have been expanded to three or four sessions, speakers of national prominence have accepted, and program chairmen have raised their original estimates of expected attendance. Thus, it is increasingly evident that the seventh Washington meeting will be well attended, well balanced in its coverage of the principal fields of science, including astronautics and space medicine, and memorable. Also it will be a pleasant and relatively convenient meeting.

AAAS headquarters and center of the meeting will be the attractive and well-appointed Sheraton-Park Hotel at the intersection of Woodley Road and Connecticut Avenue. Here will be located the AAAS Main Registration–Information Center, the Visible Directory of Registrants, the AAAS Office, the AAAS Pressroom, the AAAS Science Theatre, and the large-scale exhibits of the Annual Exposition of Science and Industry.

The Sheraton-Park's Sheraton Hall comfortably accommodates 3000 persons, yet all can see and hear well because there are no pillars and the acoustics and public-address system are good. This large ballroom, which is situated directly over the Exhibit Hall, will be the site of the AAAS general symposium, *Moving Frontiers of Science III*; the AAAS presidential address (by Laurence H. Snyder) and reception; all of the larger sessions each morning and afternoon; the evening addresses of the United Chapters of Phi Beta Kappa, Society of the Sigma Xi, and the National Geographic Society; and the AAAS Smoker for all registrants. This or other rooms in the Sheraton-Park will be used for the IGY sessions, the RESA address, the AAAS business sessions, and other events of general interest. A number of the sectional programs, such as those in chemistry, botany, zoology, medical sciences, and geology, in part, will be held in this hotel.

The Shoreham Hotel at the intersection of Calvert Street and Connecticut Avenue, and therefore adjacent to the rear of the Sheraton-Park, will be almost as convenient as the Sheraton-Park for the Visible Directory, Science Theatre, and exhibits. For that reason, many sections and societies have been assigned this hotel as headquarters. Fortunately, by itself, the Shoreham is large enough to house a fair-sized convention. Meeting the preferences of the societies named, the Shoreham will serve as headquarters for the American Society of Zoologists, the Society of Systematic Zoology, other biological groups, and the four science-teaching societies. Guests of the Shoreham, when they attend the general events or visit the exhibits at the Sheraton-Park, need only cross Calvert Street and use the latter hotel's rear or garage entrances.

The Dupont Plaza Hotel, at Dupont Circle where Connecticut and Massachusetts Avenues intersect, is a short bus ride downtown from the Sheraton-Park. It is within easy walking distance of the Mayflower Hotel, which the American Historical Society will use as its headquarters, and thus is particularly convenient for the History of Science Society, which expressed a preference for the Dupont as its headquarters.

The Statler and Sheraton-Carlton hotels, both at 16th and K Streets, are about a mile from the Sheraton-Park; the Washington and Willard hotels, between 15th and 14th Streets on Pennsylvania Avenue, are several additional blocks downtown. These last two hotels are relatively near the Smithsonian Institution. Taxis will be found most convenient for reaching the Sheraton-Park from them. (Few, if any, cities in the United States have more taxis per capita or more moderate rates). Very probably, also, AAAS chartered buses will be used to operate a continuous shuttle service between the downtown hotels and the Sheraton-Park. The meeting is as compact as possible, with a large majority of sessions at the Sheraton-Park and Shoreham. To provide adequate and comfortable meeting rooms for the remaining sessions, it was necessary to engage additional hotels.

Still other hotels will be used for auxiliary housing. These are the Roosevelt, Sheraton-Carlton, and Windsor Park. A list of the headquarters hotels for each section and participating organization—together with their street addresses—is appended, since it is an obvious convenience for each person attending the meeting to have this information before he applies for room reservations.

Housing

Beginning with this issue, the advertising pages of *Science* will carry, at frequent intervals, announcements of hotel sleeping accommodations and their rate schedules, together with a coupon which should be filled out and sent, *not* to any hotel directly, but to the AAAS Housing Bureau in Washington, D.C.

All applications for hotel rooms will be filled in the order of their receipt. Those who apply early are assured of the hotel of their first choice if the stated desired and maximum rates are within the limits of the printed rate schedules. In Washington, which is accustomed to accommodating conventions and many visitors most of the year, there is an adequate supply of hotel rooms at a wide range of rates. Several hotels have been able to quote special flat rates for their accommodations—a real advantage when rooms do not vary much in size and appointments. In other instances, it is suggested that the *maximum rate,* which you do not wish to exceed, and your *desired rate* both be stated on your coupon. Room expenses usually can be reduced substantially if rooms are shared by two persons or if suites are shared by three or more persons. Also, upon request, most hotels will place comfortable rollaway beds in rooms or suites at $2.00 or $2.50 per night.

Registration

Both the technical, or program, sessions and the special sessions are open to all interested persons. Although registration for these is not mandatory, it is expected that all who attend will wish to pay the AAAS registration fee of $3 and thus contribute a proportionate share of the heavy expenses of the meeting. (The registration fee for the spouse of a registrant, if a second Program Directory is not required, is $1.00.)

Each registrant receives the book-size General Program-Directory (a valuable

reference on all AAAS activities), convention literature, listing in the Visible Directory of Registrants, and a Convention Badge, which insures all privileges of the meeting. The badge *is* required for admission to the large-scale exhibits, the AAAS Science Theatre, the presidential address and reception, and the AAAS Smoker; refreshments are served at the last two events.

Advance registration has some decided advantages: delay at the registration desks upon arrival is eliminated; the General Program-Directory, which is sent out by first-class mail early in December, enables one, at leisure, to determine which events and sessions he particularly does not wish to overlook; and one's name is posted in the Visible Directory of Registrants as the meeting opens. (The hotel room can be added later, by the registrant himself, if he wishes.)

An announcement on advance registration and a coupon for it will also be found in the advertising pages of this issue and at intervals hereafter.

Hotels

Note: Societies are grouped in the same sequence of disciplines as the letters of the AAAS sections.

Sheraton-Park (800 rooms), 2660 Woodley Road, N.W.: AAAS; Press; AAAS Committee on the Social Aspects of Science; AAAS Sections C—Chemistry, G–Botanical Sciences, H–Anthropology, N–Medical Sciences; Alpha Chi Sigma, American Association of Clinical Chemists; National Geographic Society; American Society of Plant Physiologists, American Society of Plant Taxonomists, Botanical Society of America; American Society of Photogrammetry, Instrument Society of America; Alpha Epsilon Delta, American Association of Hospital Consultants, American College of Cardiology, American Physiological Society, American Psychiatric Association; Society for Industrial Microbiology, Washington Section; American Geophysical Union, International Geophysical Year, National Academy of Sciences, National Association of Science Writers, National Science Foundation, Scientific Research Society of America, Society of the Sigma Xi, United Chapters of Phi Beta Kappa, Washington Academy of Sciences.

Shoreham (600 Rooms), 2500 Calvert Street, N.W.: AAAS Cooperative Committee on the Teaching of Science and Mathematics; AAAS Sections F–Zoological Sciences, K–Social and Economic Sciences, Nd–Dentistry, Np–Pharmacy, Q–Education; American Society of Ichthyologists and Herpetologists, American Society of Mammalogists, American Society of Zoologists, Entomological Society of America, Systematic Section, Society of Systematic Zoology; American Society of Naturalists, Association of Southeastern Biologists, Beta Beta Beta Biological Society, Biometric Society, ENAR, Ecological Society of America, Society for the Study of Evolution, Society of General Physiologists; American Economic Association, American Political Science Association, American Society of Criminology, American Sociological Society, American Statistical Association, Association for the Psychiatric Treatment of Offenders, Character Underwriters, Inc., Institute for Research on Crime and Delinquency, Metric Association, National Academy of Economics and Political Science, New York Institute of Public Service Training, New York Institute of Criminology, Pi Gamma Mu; American College of Dentists, American Dental Association, International Association for Dental Research; American Association of Colleges of Pharmacy, American College of Apothecaries, American Pharmaceutical Association, Scientific Section, American Society of Hospital Pharmacists, National Association of Boards of Pharmacy; American Educational Research Association, International Council for Exceptional Children, National Association of Biology Teachers; National Association for Research in Science Teaching, National Science Teachers Association; Academy Conference, Conference on Scientific Manpower, Scientific Manpower Commission, Sigma Delta Epsilon, American Nature Study Society.

Statler (850 rooms), 16th and K Streets, N.W.: AAAS Sections A–Mathematics, B–Physics, D–Astronomy, M–Engineering, P–Industrial Science; Association for Computing Machinery; American Association of Physics Teachers, Chesapeake Section, American Astronautical Society, American Meteorological Society; Astronomical League; Society for General Systems Research; Engineering Manpower Commission; Operations Research Society of America; National Science Foundation.

Washington (375 rooms), 15th Street and Pennsylvania Avenue, N.W.: AAAS Section E–Geology and Geography; Association of American Geographers, Middle Atlantic Division, Geological Society of America, National Speleological Society.

Willard (450 rooms), 14th Street and Pennsylvania Avenue, N.W.: AAAS Sections I–Psychology and O–Agriculture; American Society of Agricultural Engineers, American Society of Civil Engineers; American Society of Agronomy, American Society for Horticultural Science, Gamma Sigma Delta, Society of American Foresters, Soil Conservation Society of America; American Association of Scientific Workers, Conference on Scientific Communication Problems.

Dupont Plaza (350 rooms), Dupont Circle, N.W.: AAAS Section L–History and Philosophy of Science; History of Science Society, Philosophy of Science Association.

Roosevelt (300 rooms), 2101 16th Street, N.W.

Sheraton-Carlton (250 rooms), 16th and K Streets, N.W.

Windsor Park (150 rooms), 2300 Connecticut Avenue, N.W.

Forthcoming Events

August

17. American College of Hospital Administrators, 24th annual, Chicago, Ill. (ACHA, 620 N. Michigan Ave., Chicago.)

17–21. Health Conf., 7th annual, University Park, Pa. (M. Cashman, Pennsylvania Dept. of Health, P.O. Box 90, Harrisburg.)

18–19. American Astronautical Soc., Western meeting, Palo Alto, Calif. (N. V. Petersen, Lockheed Missile Systems Div., Palo Alto.)

18–20. National Council of Teachers of Mathematics, Greeley, Colo. (M. H. Ahrendt, 1201 16 St., NW, Washington 6.)

18–21. Conservation Education Assoc., 5th annual, Salt Lake City, Utah. (S. D. Mulaik, Biology Dept., University of Utah, Salt Lake City.)

18–21. Heat Transfer, AIChE conf., Evanston, Ill. (F. J. Van Antwerpen, AIChE, 25 W. 45 St., New York 36.)

18–22. Clinical Chemistry Workshop, Houston, Tex. (Division of Clinical Chemistry, Dept. of Biochemistry, Baylor Univ., College of Medicine, Houston.)

18–22. Occupational Medicine and Toxicology, 2nd Inter-American conf., Miami, Fla. (W. B. Deichmann, Dept. of Pharmacology, Univ. of Miami School of Medicine, Coral Gables, Fla.)

18–22. Plant Science Seminar, 35th annual, Big Rapids, Mich. (E. P. Claus, Div. of Pharmacy, Ferris Inst., Big Rapids.)

18–22. Semiconductors, intern. conf., IUPAP, Rochester, N.Y. (D. L. Dexter, Dept. of Physics, Univ. of Rochester, Rochester.)

18–23. New England Assoc. of Chemistry Teachers, 20th summer, Kingston, R.I. (J. A. Martus, College of the Holy Cross, Worcester 10, Mass.)

18–25. Religion in the Age of Science, 5th summer conf., Star Island, N.H. (Institute on Religion in an Age of Science, 280 Newton St., Brookline 46, Mass.)

20–27. Photofluorography, intern. cong., Stockholm, Sweden. (International Cong. of Photofluorography, P.O. Box 5097, Stockholm 5.)

20–27. Australian and New Zealand Assoc. for the Advancement of Science, 33rd cong., Adelaide, Australia. (J. R. A. McMillan, Science House, 157–161 Gloucester St., Sydney.)

20–27. Genetics, 10th intern. cong., Montreal, Canada. (J. W. Boyes, Dept. of Genetics, McGill Univ., Montreal.)

21–23. American Farm Economic Assoc., Winnipeg, Canada. (L. S. Hardin, Dept. of Agricultural Economics, Purdue Univ., Lafayette, Ind.)

21–23. Chemical Organization of Cells, Normal and Abnormal, Madison, Wis. (J. F. A. McManus, Dept. of Pathology, Univ. of Alabama Medical Center, Birmingham.)

21–24. Cenozoic of Western Montana, field conf., Missoula, Mont. (A. E. Wood, Soc. of Vertebrate Paleontology, Dept. of Biology, Amherst College, Amherst, Mass.)

23–25. Rural Sociology Soc., annual, Pullman, Wash. (H. F. Lionberger, Dept. of Rural Sociology, Univ. of Missouri, Columbia.)

24–28. American Inst. of Biological Sciences, annual, Bloomington, Ind. (H. T. Cox, AIBS, 2000 P St., NW, Washington 6.)

The following 25 meetings are being held in conjunction with the AIBS meetings at Bloomington, Ind.

American Bryological Soc., annual. (Mrs. V. S. Bryan, Botany Dept., Duke Univ., Durham, N.C.)

American Fern Soc., annual. (Miss M. E. Faust, 501 University Pl., Syracuse 10, N.Y.)

American Microscopical Soc., annual. (D. G. Frey, Dept. of Zoology, Indiana Univ., Bloomington.)

American Phytopathological Soc., 50th anniversary. (W. B. Hewitt, Dept. of Plant Pathology, Univ. of California, Davis.)

American Soc. for Horticultural Science, annual. (R. E. Marshall, Dept. of Horticulture, Michigan State Univ., East Lansing.)

American Soc. of Ichthyologists and Herpetologists, annual. (R. Conant, Philadelphia Zoological Garden, 34th and Girard Ave., Philadelphia 4, Pa.)

American Soc. of Limnology and Oceanography. (B. H. Ketchum, Woods Hole Oceanographic Inst., Woods Hole, Mass.)

American Soc. of Naturalists. (B. Wallace, Long Island Biological Assoc., Cold Spring Harbor, N.Y.)

American Soc. of Parasitologists, annual. (P. E. Thompson, Research Div., Parke, Davis & Co., Detroit 32, Mich.)

American Soc. of Plant Physiologists, annual. (G. R. Noggle, Dept. of Botany, Univ. of Florida, Gainesville.)

American Soc. of Plant Taxonomists. (R. F. Thorne, Botany Dept., State Univ. of Iowa, Iowa City.)

American Soc. of Zoologists. (S. Crowell, Dept. of Zoology, Indiana Univ., Bloomington.)

Biometric Soc., ENAR. (T. W. Horner, General Mills, Inc., 400 Second Ave., S., Minneapolis 1, Minn.)

Botanical Soc. of America, annual. (H. C. Bold, Dept. of Botany, Univ. of Texas, Austin 12.)

Ecological Soc. of America. (J. E. Cantlon, Dept. of Botany and Plant Pathology, Michigan State Univ., East Lansing.)

Mycological Soc. of America, annual. (E. S. Beneke, Dept. of Botany and Plant Pathology, Michigan State Univ., East Lansing.)

National Assoc. of Biology Teachers. (P. Fordyce, Broad Ripple High School, Indianapolis, Ind.)

Nature Conservancy. (G. B. Fell, 4200 22 St., NE, Washington 18.)

Phycological Soc. of America, annual. (W. A. Daily, Dept. of Botany, Butler Univ., Indianapolis 7, Ind.)

Potato Assoc. of America, annual. (R. V. Akeley, Crops Research Div., USDA, Plant Industry Station, Beltsville, Md.)

Society for Industrial Microbiology, annual. (C. L. Porter, Dept. of Biological Sciences, Purdue Univ., West Lafayette, Ind.)

Society of Protozoologists, annual. (N. D. Levine, College of Veterinary Medicine, Univ. of Illinois, Urbana.)

Society for the Study of Development and Growth. (R. O. Erickson, Dept. of Botany, Univ. of Pennsylvania, Philadelphia 4.)

Society of Systematic Zoology. (R. E. Blackwelder, Box 500, Victor, N.Y.)

Tomato Genetics Cooperative. (E. C. Stevenson, Horticulture Dept., Purdue Univ., West Lafayette, Ind.)

24–29. Atmospheric Diffusion and Air Pollution, intern. symp., Oxford, England. (F. N. Frenkiel, Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md.)

24–29. Mental Health, world federation,

11th annual, Vienna, Austria. (Miss E. M. Thornton, World Federation for Mental Health, 19 Manchester St., London, W.1, England.)

24–30. Astronautical Cong., 9th intern., Amsterdam, Netherlands. (A. G. Haley, International Astronautical Federation, 1735 DeSales St., Washington.)

24–30. Prehistoric and Protohistoric Science, 5th intern. cong., Hamburg, Germany. (Büro des Internationalen Kongresses für Vor- und Frühgeschichte, c/o Fremdenverkehrs- und Kongresszentrale, Hamburg 1, Bieberhaus, Hachmannplatz.)

25–28. Institute of Mathematical Statistics, annual, Cambridge, Mass. (G. E. Nicholson, Jr., Dept. of Statistics, Univ. of North Carolina, Chapel Hill.)

25–28. Mathematical Assoc. of America, 39th summer, Cambridge, Mass. (H. M. Gehman, Univ. of Buffalo, Buffalo 14, N.Y.)

25–29. Infrared Spectroscopy Inst., annual, Nashville, Tenn. (J. R. Lawson, Fisk Univ., Nashville 8.)

25–29. Electronic Properties of Metals at Low Temperatures, IUPAP colloquium, Geneva, N.Y. (M. D. Fiske, General Electric Co., P.O. Box 1088, Schenectady, N.Y.)

25–30. American Mathematical Soc., 63rd summer, Cambridge, Mass. (AMS, 190 Hope St., Providence 6, R.I.)

27–29. American Sociological Soc., annual, Seattle, Wash. (Miss M. W. Riley, ASS, New York Univ., Washington Sq., New York 3.)

27–29. Diseases in Nature Communicable to Man, 13th annual intern. Northwest conf., Hamilton, Montana. (W. L. Jellison, National Microbiological Inst., Rocky Mountain Laboratory, USPHS, Hamilton.)

27–3. British Assoc. for the Advancement of Science, Glasgow, Scotland. (BAAS, Burlington House, London, W.1, England.)

28–2. Biometric Soc., ENAR, Ottawa, Ont., Canada. (T. W. Horner, General Mills, Inc., 400 Second Ave., S., Minneapolis 1, Minn.)

28–3. Combustion Symp., 7th intern., London and Oxford, England. (Combustion Inst., 936A Union Trust Bldg., Pittsburgh 19, Pa.)

31–6. Housing and Town Planning, 24th cong., Liége, Belgium. (International Federation for Housing and Town Planning, Parkhotel, Molenstraat 53, The Hague, Netherlands.)

31–8. Corpuscular Photography Colloquium, 2nd intern. (by invitation), Montreal, Canada. (P. Demers, Institut de Physique, Université de Montreal, P.Q.)

September

1–6. Biochemistry, 4th intern. cong., Vienna, Austria. (O. Hoffmann-Ostenhof, 1, Chemisches Institut der Universität, Währingerstrasse 42, Vienna IX.)

1–7. Psychotherapy, intern. cong., Barcelona, Spain. (M. de la Cruz, Clinica Psiquiatrica Universitaria, Facultad de Medicina, Barcelona.)

1–9. Analogy Computation, 2nd intern., Strasbourg, France. (F. H. Raymond, 138 Boulevard de Verdun, Courbevoie, Seine, France.)

1–13. Peaceful Uses of Atomic Energy,

2nd intern. conf., Geneva, Switzerland. (L. D. P. King, Atomic Energy Commission, Washington 25.)

2–4. Allergy, 4th European cong., London, England. (British Assoc. of Allergists, St. Mary's Hospital, London, W.2.)

2–4. Vertebrate Phylogeny Symp., Soc. of Vertebrate Paleontology and Soc. for the Study of Evolution, Ann Arbor, Mich. (J. T. Gregory, Peabody Museum, Yale Univ., New Haven, Conn.)

2–5. Alaskan Science Conf., 9th, College. (R. L. Rausch, Alaska Div., AAAS, Box 960, Anchorage, Alaska.)

2–5. American Physiological Soc., 10th autumn, London, Ontario, Canada. (APS, 9650 Wisconsin Ave., Washington 14.)

2–6. Engineering Societies, Pan American Federation, 5th, Montreal, Canada. (L. A. Wright, Engineering Inst. of Canada, 2050 Mansfield St., Montreal 2.)

2–6. Glaucoma, intern. symp., Liége, Belgium. (R. Weekers, Clinique Ophtalmologique, Hôpital de Baviere, Liége.)

3–5. Cryogenic Engineering Conf., annual, Cambridge, Mass. (K. D. Timmerhaus, Chemical Engineering Dept., Univ. of Colorado, Boulder.)

3–6. Blood Transfusion, 7th intern. cong., Rome, Italy. (G. Marinone, Clinica Medica, Policlinico, Pavia, Italy.)

3–10. Cybernetics, 2nd intern. cong., Namur, Belgium. (Association Internationale de Cybernetique, 13, rue Basse-Marcelle, Namur.)

4–5. Air Pollution, 2nd intern, conf., New York, N.Y. (American Soc. of Mechanical Engineers, 29 W. 39 St., New York 18.)

4–6. American Political Science Assoc., St. Louis, Mo. (E. M. Kirkpatrick, APSA, 1726 Massachusetts Ave., NW, Washington 6.)

4–6. Calorimetry Conf., 13th annual, Lemont and Chicago, Ill. (D. H. Andrews, Dept. of Chemistry, Johns Hopkins Univ., Baltimore, Md.)

5–10. Formal Deductive Systems in Mathematics and in Natural Science, symp., Brussels, Belgium. (International Union for the History and Philosophy of Science, 4, rue Thenard, Paris 5e, France.)

5–13. Tropical Medicine and Malaria, 6th intern. cong., Lisbon, Portugal. (M. R. Pinto, Instituto de Medicina Tropical, Lisbon.)

6–12. Pharmaceutical Sciences, 18th intern. cong., Brussels, Belgium. (J. W. Birza, 196 Bilderdijkstraat, Amsterdam W, Netherlands.)

7–11. Diseases of the Chest, 5th intern. cong., Tokyo, Japan. (M. Kornfeld, American College of Chest Physicians, 112 Chestnut St., Chicago 11, Ill.)

7–12. Laurentian Hormone Conf., AAAS, annual, Blaney Park, Mich. (G. Pincus, 222 Maple Ave., Shrewsbury, Mass.)

7–13. Hematology, 7th intern. cong., Rome, Italy. (S. Haberman, Baylor Univ. Hospital, 3500 Gaston Ave., Dallas, Tex.)

7–20. Industrial Chemistry, 31st intern. cong., Liége, Belgium. (Society of Industrial Chemistry, 28, rue Saint Dominique, Paris 7e, France.)

8–12. Spectroscopy Colloquium, 7th Intern., Liége, Belgium. (Association des Ingénieurs de l'Université de Liége, 22, rue Forgeur, Liége.)

8–13. International Council of Aeronautical Sciences, Madrid, Spain. (R. R. Dexter, Inst. of Aeronautical Sciences, 2 E. 64 St., New York 21.)

8–17. Sociology, 18th intern. cong., Nürnberg, Germany. (International Inst. of Sociology, Findelgasse 7–9, Nürnberg, Germany.)

9–11. Engineering Meteorology, 2nd natl. conf., Ann Arbor, Mich. (K. C. Spengler, American Meteorological Soc., 3 Joy St., Boston 8, Mass.)

11–19. Conservation of Nature and Natural Resources, 6th general assembly, Athens and Delphi, Greece. (International Union for Conservation of Nature and Natural Resources, 31, rue Vautier, Brussels, Belgium.)

13–17. Bronchoesophagology, 7th intern. cong., Kyoto, Japan. (C. L. Jackson, 3401 N. Broad St., Philadelphia 40, Pa.)

14–20. Ceramics Cong., 6th intern., Wiesbaden, Germany. (Sekretariat des VI Internationalen Keramischen Kongresses, Reuterstrasse 235, Bonn/Rh., Germany.)

14–21. Cardiology, 3rd world cong., Brussels, Belgium. (F. Van Dooren, 80, rue Mercelis, Brussels.)

15–19. Instrument-Automation Conf., 13th annual, Philadelphia, Pa. (H. S. Kindler, Instrument Soc. of America, 313 Sixth Ave., Pittsburgh 22, Pa.)

15–20. Agriculture, European Confederation 10th anniversary, Vienna, Austria. (European Confederation of Agriculture, Pestalozzistrasse 1, Brugg, Argovie, Switzerland.)

15–20. Carboniferous Stratigraphy and Geology, 4th intern. cong., Heerlen, Netherlands. (Secretary, 4th Carboniferous Cong., Geological Bureau, Akerstraat 86–88, Heerlen.)

16–20. Nuclear Electronics, intern. symp., Paris, France. (Colloque Electronique Nucléaire, 10, avenue Pierre-Larousse, Malakoff (Seine), France.)

16–24. Glacier Movement Symp., Chamonix, France. (International Assoc. of Scientific Hydrology, 61, rue de Ronces, Gentrugge, Belgium.)

21–25. Differential Anthropology, 5th intern. cong., Amsterdam, Netherlands. (R. A. M. Bergman, Royal Tropical Inst., Linnaeusstraat 2A, Amsterdam.)

21–28. Poultry Science, 11th world cong., Mexico, D.C., Mexico. (E. Karpoff, Agricultural Marketing Service, USDA, Washington 25.)

22–24. Standards Engineers Soc., 7th annual, Philadelphia, Pa. (Standards Engineers Soc., Box 281, Camden 1, N.J.)

22–25. Scientific Instruments of the 16th to the 19th Century, symp., Frankfurt/Main, Germany. (International Union for the History and Philosophy of Science, 4, rue Thenard, Paris 5e, France.)

22–27. High-Speed Photography, 4th intern. cong., Cologne, Germany. (Royal Photographic Soc., 16 Princes Gate, London, S.W.7, England.)

23–25. Fat Research, 3rd intern. cong., Seville, Spain. (J. M. Martinez, Instituto de la Grasa, Avenida de Heliopolis, Seville.)

23–30. Rheology, 3rd intern. cong., Bad Oeynhausen, Germany. (R. S. Marvin, Rheology Section, Natl. Bureau of Standards, Washington 25.)

Letters

General Semantics

There is unquestionably a need for such a book as Martin Gardner's *Fads and Fallacies in the Name of Science* [reviewed by John Pfeiffer in *Science* (**126**, 1296 [1957]). But there is always a danger that an overzealous debunker will throw out the baby with the bath water. And while certain "fads and fallacies" are obviously so, our debunker, who, after all, cannot be an informed specialist in every field of science, might easily be guilty of some "fallacies" himself. Such seems to be the case with Gardner, whose lumping of Alfred Korzybski and *General Semantics* [*Nonaristotelian Systems and General Semantics*] with the inanities of Velikovsky, Hubbard, and Reich is comparable to lumping the latter three with B. F. Skinner or Carl Rogers or Julian Huxley.

The scientific "respectability" of Korzybski's *General Semantics* is no longer seriously questioned (except by Gardner), for as a school of thought in the behavioral sciences it has actually gained at least as much "respectability" as Freud's psychoanalysis, if not more, and has blossomed into a significant International Society for General Semantics. Courses in general semantics are currently being offered by the University of Chicago and other universities of considerable "respectability," and the literature of general semantics features such prominent names as those of S. I. Hayakawa, Wendell Johnson, and Anatol Rapaport. Further, the large number of psychiatrists, psychologists, and other scientists who would disagree with Gardner's misclassification of general semantics as a "fad" or "fallacy" would seem to indicate that Gardner's ambitious attempt to draw a precise line between science and pseudoscience is neither 100 percent trustworthy nor 100 percent successful. Actually, any attempt to set up an "infallible authority" to distinguish between science and nonsci ɔce is bound to fail. Both Rome and Moscow have tried this and made themselves look rather silly.

EDD DOERR

Bogotá, Colombia

I agree with most of Edd Doerr's statements, having made the same points in my book. In both the "Introduction" and the final chapter, I discuss at some length the spectrum of science and pseudoscience and the extreme difficulty of drawing a precise line between them. I approached Count Korzybski's work by specifically pointing out that he was not to be classed with most of the men mentioned in the book (I made a similar distinction in respect to J. B. Rhine), and I emphasized the fact that I was attacking only the doctrines which were original with the Count.

Many people do not realize that "semantics" is an old and highly respected branch of meaning analysis and that the Count simply drew heavily from this tradition and popularized it. College courses in semantics, even those taught by the Count's reputed followers, are little more today than elementary excursions into this field. Where Korzybski simply passed on a semantic commonplace, naturally no one disagrees, but in respect to those doctrines which are peculiar to the Count, one would be hard put to find a single philosopher of science today who did not agree with the acid opinion of Ernest Nagel, quoted in my book.

MARTIN GARDNER

Dobbs Ferry, New York

"Paramecium Controversy"

A recent addition to what is apparently developing into "the *Paramecium* controversy" was contributed by Kellogg (*1*), who presents a view of the main reason for disagreement between Gelber (*2*) and Jensen (*3*) that is rather surprising. According to Kellogg, Gelber hypothesizes that learning is characteristic of all living tissue, while Jensen restricts learning to the higher levels on the phyletic scale. These extreme views are not clearly expressed by either Gelber or Jensen in the articles cited by Kellogg.

Kellogg cites other studies of apparent learning in paramecia and, in referring to one report, states that French (*4*) "gives seemingly unequivocal evidence of trial-and-error learning in paramecia." "Unequivocal evidence" is a slippery quantity and, as Kellogg points out, there have been reports of negative findings also. Gelber, in an early publication (*5*), referred to many of the articles that Kellogg accuses both her and Jensen of neglecting to use as evidence.

In a very recent article Katz and Deterline (*6*) report the results of a replication of Gelber's basic study (*5*). The experimental design included several control groups set up for the purpose of testing the conflicting views of Gelber and Jensen. Jensen attributes the observed change in the behavior of paramecia in the Gelber studies to the presence of food, apart from any inference of learning. Katz and I came to the conclusion that Jensen's more conservative explanation is more credible than Gelber's. This does not mean that we deny that paramecia have the ability to learn. That phenomenon remains a fascinating possibility. We do insist that Gelber's technique does not isolate the phenomenon in an unequivocal fashion.

Apparently perception is an even bigger problem in psychology than is usually realized. Katz and I observed the be-

havior of our paramecia in replications of studies reported by Day and Bentley (*7*) and Smith (*8*) as well as of the study by Gelber. The paramecia behaved in some cases exactly as described by those authors, but our perceptual interpretations of the behavior we observed did not permit us to state that we saw paramecia behaving in a manner that indicated that a learned modification of behavior had occurred. Gelber perceives the same changes as evidence of learning. Now we find that we do not even view the Gelber-Jensen controversy in the same way that Kellogg does. Until a more satisfactory method is devised, the question of whether or not paramecia can learn will remain a perceptual one and, as such, will not receive a scientific answer.

WILLIAM A. DETERLINE
Department of Psychology,
Alma College, Alma, Michigan

References

1. W. N. Kellogg, *Science* **127**, 766 (1958).
2. B. Gelber, *J. Comp. and Physiol. Psychol.* 45, 58 (1952).
3. D. D. Jensen, *Science* **125**, 191 (1957).
4. J. W. French, *J. Exptl. Psychol.* 26, 609 (1940).
5. B. Gelber, *Science* **126**, 1340 (1957).
6. M. S. Katz and W. A. Deterline, *J. Comp. and Physiol. Psychol.* 51, 243 (1958).
7. L. M. Day and M. Bentley, *J. Animal Behavior* 1, 67 (1911).
8. S. Smith, *J. Comp. Neurol.* **18**, 499 (1908).

There is little I can say (*1*) in reply to William A. Deterline except that I find no cause for basic disagreement either with the tone of his letter or with the research report of Katz and Deterline (*2*).

My only regret is that the meaning of my original comments appears not to have been quite clear. I tried to point out that centuries before there was any research whatever on the learning or nonlearning of paramecia, philosophers had debated the question of whether low organisms can learn and "have minds."

Today, when we do have research data to support our speculations, there still seems to exist the same sort of controversy. For now the experimental results are open to two interpretations: (i) that they demonstrate learning in paramecia and (ii) that they do not demonstrate learning. If expressed in terms of hypotheses, the position taken by Gelber (*3*) is the positive one—namely, that paramecia and probably other low organisms can learn. The hypothesis which appears to describe Jensen's position (*4*) is that lower organisms move mechanically and are incapable of learning. These two positions are not unrelated to the vitalistic-mechanistic controversy, with roots far in the past. Thus Descartes held that all animals—high as well as low—behave like machines and that man alone possesses higher "mental" abilities.

I seem to have detected in some recent reports that have been written on the

subject a kind of emotional or anthropocentric intolerance which looks with scorn upon the possibility of learning in lower organisms—as if the very thought of it were beneath the level of scientific thinking. Happily, there is no evidence of such a bias in the article by Katz and Deterline (*2*).

Those who maintain that learning in paramecia or in other Protozoa has *not* been demonstrated should acquaint themselves with the literature on the subject and should not close the door upon such a possibility. Some of this literature was cited in my original note (*1*). Those who adopt the more liberal attitude and hold that the available data *do* demonstrate learning should still realize that there is room for a negative position. Let not emotional bias for either view disturb a fair and intelligent appraisal of the evidence.

We need much more evidence before either position can be swept aside.

W. N. KELLOGG

Department of Psychology,
Florida State University, Tallahassee

References

1. W. N. Kellogg, *Science* **127**, 766 (1958).
2. M. S. Katz and W. A. Deterline, *J. Comp. and Physiol. Psychol.* **51**, 243 (1958).
3. B. Gelber, *Science* **126**, 1340 (1957).
4. D. D. Jensen, *ibid.* **125**, 191 (1957); **126**, 1341 (1957).

Equipment

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Science does not assume responsibility for the accuracy of the information. A coupon for use in making inquiries concerning the items listed appears on page 166.

■ MOISTURE METER is a portable, transistorized instrument powered by mercury batteries. The instrument measures d-c resistance of woods to determine moisture content from 6 to 70 percent in three ranges. Normal battery life in the instrument is 2 yr; approximately 100,000 tests may be made before replacement becomes necessary. (Moisture Register Co., Dept. 151)

■ RADIOACTIVE-GAS SURVEY METER is intended primarily as a tritium detector. It consists of an ionization chamber through which air is continuously drawn by means of a blower operated by a self-contained storage battery. Ion current is indicated on a meter relay which can be adjusted to actuate an alarm. Half-scale sensitivities are 1, 10, 100, and 1000 μc of tritium per liter. Gas-flow rate is 325 liter/min. The instrument can be operated for 12 hr without recharging the battery. (Levinthal Electronic Products, Inc., Dept. 161)

■ TORSIONAL-DAMPING TESTER uses free oscillations for investigation of torsional elasticity and damping effects in plastics, rubber, and similar materials. The instrument's testing chamber can be heated or cooled by auxiliary apparatus and can be filled with protective gas. Oscillation of an inertia disc suspended from the specimen is photographed by means of a mirror attached to the disc. Interchange of discs permits variation of frequency from about 0.1 to 20/sec. (William J. Hacker & Co., Inc., Dept. 156)

■ TIME-INTERVAL MEASURING INSTRUMENT operates by converting the time interval being measured to an electrical pulse of proportional height. The pulse thus obtained is fed to a 20-channel pulse-height analyzer. The channel in which the pulse is registered measures the original time interval, each channel corresponding to a known interval. Intervals in the nanosecond (10^{-9} sec) range are said to be measurable. (Eldorado Electronics, Dept. 154)

■ COLOR-TOLERANCE COMPUTER simplifies specifying and classifying color by reducing tristimulus values to a single numerical value, ΔE. This value is indicated on a dial calibrated in NBS units. The instrument further calculates the type and magnitude of color deviation in lightness-darkness, redness-greenness and yellowness-blueness. Color corrections can be simulated on the computer to determine their effects before actual changes are made. (Instrument Development Laboratories, Inc., Dept. 168)

■ COUNTING-RATE METER features seven counting ranges from 200 to 200,000 counts/min. Time constants of 3, 10, and 30 sec are provided for short- or long-term observation. High-voltage regulated power, continuously variable from 550 to 2000 v, is supplied with the instrument. Regulation is 0.1 percent for 1 percent change in line voltage. Provision is made for operation of a 1-ma or a 10-mv recorder. (B. J. Electronics, Dept. 162)

■ REMOTE-HANDLING TOOL is available with either a 3- or 4-ft handle assembly. Four different jaw attachments permit handling of objects ranging in size from a 7-in. sphere to a 1/32-in. nut. Four mounting plates are provided for storage of the jaws. The handle may be remotely withdrawn or inserted into the jaw attachments without manual contact. (Atomic Accessories Inc., Dept. 163)

■ TIME-INTERVAL INDICATOR is applicable to measurement of the time interval between any two points of a single or double pulse. The instrument comprises two attenuators and two cathode followers, a step-variable delay line and a

continuously-variable delay line of total delays 0.5 and 6.1 μsec respectively, pulse-forming circuit, multivibrator, and two gating circuits. The instrument is used in conjunction with an oscilloscope for observation of signals. (AD-YU Electronics Laboratory, Inc., Dept. 164)

■ DIRECT-VIEW STORAGE TUBE retains images on its screen for more than 5 min. Black background of the tube permits viewing in high ambient light. An erasing gun allows the user to eliminate undesired areas. Tubes are available with electrostatic or electromagnetic deflection and focusing, and in a variety of sizes. (Allen B. DuMont Laboratories, Inc., Dept. 165)

■ OSCILLOGRAPHIC RECORDER provides high-resolution oscillograms from galvanometer light beams on electrophotographic paper. The developed record can be viewed in 1 sec or less at paper speeds of 4 in./sec or higher. Sensitizing, exposure, developing, and fixing are done at a continuous rate for recording speeds of ¼ to 16 in./sec. As many as 40 channels can be used on 14-in. paper. A removable trace identifier provides for overlap of traces. The supply spool holds 500 ft of paper. Timing lines are inserted at intervals of 0.01, 0.1, or 1 sec. (Century Electronics and Instruments, Inc., Dept. 167)

■ GALVANOMETER ANALYZER is a portable instrument for testing mirror galvanometers of the type commonly used in recording oscillographs. Damping, frequency response, static balance, and sensitivity are evaluated. The instrument duplicates operating conditions by using a temperature-controlled magnet block with dummy galvanometers in all unused channels. Static balance is checked by turning the instrument on its side. (North Atlantic Industries Inc., Dept. 171)

■ HIGH-VACUUM COMPONENTS designed for quick interconnection in a variety of arrangements permit evacuation to 10^{-7} mm-Hg. A total of 21 components is available, including the following: a 2-in. diffusion pump rated at 150 ft^3/min at 10^{-6} mm-Hg; thermocouple and ionization gages; liquid-nitrogen cold trap; high-vacuum valves; flexible connectors; adapters; and manifold sections. (N.R.C. Equipment Corporation, Dept. 174)

■ PRESSURE-TRANSDUCER CALIBRATOR automatically performs the calibration of 1 to 12 pressure transducers. Quantitative data on linearity, hysteresis, drift, and sensitivity are provided. Calibration is dynamic. Data are presented on an *X-Y* recorder and on digital counters. (Allegany Instrument Co., Inc., Dept. 178)

■ ENVIRONMENTAL CHAMBERS, for use with vibration machines, are portable. The chambers are moved by permanently attached fork lifts, electrically or manually controlled. Height may be adjusted to fit vibrators of 2500-lb force. Chambers have removable bottom and side panels. Temperature range is – 100° to + 600°F controlled to ± 2°F. Liquid CO_2 provides cooling. Work space is up to 5 by 5 by 5 ft. (Tenney Engneering Inc., Dept. 181)

■ BLAST BURNER for glassworking has five different tips of 1.5- through 6-mm orifice diameter mounted on a revolving turret. The flame stays on as the turret is rotated. The burner operates equally well on natural, manufactured, or cylinder gas up to a pressure of 10 lb/in.². Oxygen pressure may be 5 to 15 lb/in.². (Will Corporation, Dept. 176)

■ STOP WATCHES have dial 2.36 in. in diameter. Models are available with a variety of ranges and sensitivities, with electrical contacts for operation of optical or acoustic signals, or with electromagnetic starting, stopping, and resetting. (Herman H. Sticht Co., Inc., Dept. 180)

■ AUTOMATIC PIPETTE, consisting of a fixed-volume pipette permanently attached to a double-bore stopcock, may be filled without adjustment to reference mark. The contained sample can be washed out by a measured amount of a second liquid. (Arthur H. Thomas Co., Dept. 175)

■ DIGITAL-TO-ANALOG CONVERTER converts coded-decimal and straight-decimal inputs to proportional d-c voltage. Input may be keyboard, punched card, or punched tape. Electronic switching, in which transistor and magnetic circuits are utilized, is used in the device; there are no vacuum or gas tubes. (Electro Instruments Inc., Dept. 179)

■ POTENTIOMETER achieves accuracy of 0.0015 percent in voltage measurement and 0.003 percent in current measurement. The standard-cell reference of the instrument, accurate to 0.001 percent, and the voltage dividers, accurate to 0.0001 percent, may be used separately. The standard-cell reference consists of three saturated standard cells in a 0.01°C oven. A d-c amplifier integral with the instrument is used as a galvanometer to compare an unknown voltage with the ratio-box output voltage. Extension to current measurement is achieved by adding current-scaling resistors. Voltage scales are 1 and 4 v; current scales 1, 4, 10, and 40 ma. (Julie Research Laboratories, Inc., Dept. 173)

JOSHUA STERN
National Bureau of Standards

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The General Program-Directory of the 125th Meeting of the AAAS in Washington, D.C., Dec. 26–31, 1958, will be available to anyone, at cost, within the first week in December—whether he can attend the Meeting or not. You will want the General Program-Directory for your reference shelf.

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2. The six sessions of the Conference on Scientific Communication Problems.
3. Programs of the 18 AAAS sections (symposia and contributed papers).
4. Programs of the more than 90 participating societies.
5. The Special Sessions: AAAS, Academy Conference, Conference on Scientific Manpower, National Geographic Society, Phi Beta Kappa, Sigma Xi, RESA.
6. Details of the Sheraton-Park Hotel—center of the Meeting—and of the other hotels and session sites.
7. Titles of the latest foreign and domestic scientific films to be shown in the AAAS Science Theatre.
8. Exhibitors in the 1958 Annual Exposition of Science and Industry and descriptions of their exhibits.

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1. AAAS officers, staff, committees for 1958.
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8. Section committees (Council members) in detail.
9. Local committees.
10. Future Meetings of the AAAS through 1962.
11. New and current activities of the AAAS.

Advance Registration

Advance registration has these decided advantages: 1) You avoid delay at the Registration Center upon arrival; 2) You receive the General Program-Directory in ample time to decide, unhurriedly, which events and sessions you particularly wish to attend; 3) Your name is posted in the Visible Directory as the Meeting opens.

The following coupon may be used both by advance registrants and by those who wish only the advance copy of the General Program-Directory.

— THIS IS YOUR COUPON FOR AN ADVANCE COPY OF THE GENERAL PROGRAM-DIRECTORY —

1a. ☐ Enclosed is $3.00 for my advance Registration Fee which brings me the Program-Directory, Convention Badge, and all privileges of the Meeting.

1b. ☐ Enclosed is $2.00 for only the Program-Directory. (It is understood that, if I should attend the Meeting later, the Badge—which is necessary for all privileges of the Meeting—will be secured for $1.00 more.)
(Check one)

2. FULL NAME (Dr., Miss, etc.) .....
(Please print or typewrite) (Last) (First) (Initial)

3. ACADEMIC, PROFESSIONAL, OR BUSINESS CONNECTION .....

4. OFFICE OR HOME ADDRESS .....
(For receipt of Program-Directory)

5. YOUR FIELD OF INTEREST .....

6. CONVENTION ADDRESS .....
(May be added later, after arrival)

Please mail this Coupon and your check or money order for $3.00 or $2.00 to the
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
1515 Massachusetts Avenue, N.W., Washington 5, D.C.

APPLICATION FOR HOTEL RESERVATIONS

125th AAAS MEETING

Washington, D.C., December 26-31, 1958

The list of hotels and their rates and the reservation coupon below are for your convenience in making your hotel room reservation in Washington. Please send your application, *not* to any hotel directly, but to the AAAS Housing Bureau in Washington and thereby avoid delay and confusion. The experienced Housing Bureau will make assignments promptly; a confirmation will be sent you in two weeks or less.

As in any city, single-bedded rooms at minimum rates may become scarce; double rooms for single occupancy cost more; for a lower rate, share a twin-bedded room with a colleague. Most hotels will place comfortable rollaway beds in rooms or suites at $2.00 to $2.50 per night. Mail your application *now* to secure your first choice of desired accommodations. All requests for reservations must give a definite date and estimated hour of arrival, and also probable date of departure.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Rates for Rooms with Bath

Hotels with an asterisk have sessions in their public rooms. For a list of headquarters of each participating society and section, see page 151, *Science*, July 18.

Hotel	Single	Double Bed	Twin Bed	Suite
*Dupont Plaza	$10.00–11.00	$13.00–14.00	$13.00–14.00	$21.00–27.00
*Sheraton-Park	8.00–12.00	12.00–14.50	11.00–16.00	20.00–60.00
*Shoreham	all 9.00	all 12.00	all 12.00	20.00–50.00
*Statler	all 10.00	all 14.00	all 14.00	24.00–30.00
*Washington	7.00– 8.00	11.00–12.50	11.00–12.50	24.50–45.00
*Willard	10.00–12.50	13.00–17.00	14.00–18.00	25.00–35.00
Roosevelt	7.00– 9.00		10.00–12.00	18.00–24.00
Sheraton-Carlton	12.00–17.00		17.00–21.00	
Windsor Park	all 9.00	all 14.00	all 14.00	13.00–18.00

THIS IS YOUR HOUSING RESERVATION COUPON

AAAS Housing Bureau
1616 K Street, N.W.
Washington 6, D.C.

Date of Application .....

Please reserve the following accommodations for the 125th Meeting of the AAAS in Washington, D.C., Dec. 26–31, 1958:

TYPE OF ACCOMMODATION DESIRED

Single Room ..... Desired Rate ..... Maximum Rate .....

Double-Bedded Room ..... Desired Rate ..... Maximum Rate ..... Number in party .....

Twin-Bedded Room ..... Desired Rate ..... Maximum Rate .....

Suite ..... Desired Rate ..... Maximum Rate ..... Sharing this room will be:

(Attach list if this space is insufficient. The name and address of each person, including yourself, must be listed.)

.....

.....

First Choice Hotel ..... **Second Choice Hotel** ..... **Third Choice Hotel** .....

DATE OF ARRIVAL ..... DEPARTURE DATE .....
(These must be indicated—add approximate hour, a.m. or p.m.)

NAME .....
(Individual requesting reservation) (Please print or type)

ADDRESS .....
(Street) (City and Zone) (State)

Mail this now to the Housing Bureau. **Rooms will be assigned and confirmed in order of receipt of reservation.**

PERSONNEL PLACEMENT

CLASSIFIED: 25¢ per word, minimum charge $4.25. Use of Box Number counts as 10 additional words. Payment in advance is required.

COPY for classified ads must reach SCIENCE 2 weeks before date of issue (Friday of every week).

DISPLAY: Rates listed below—no charge for Box number. Monthly invoices will be sent on a charge account basis — provided that satisfactory credit is established.

Single insertion	**$26.00 per inch**
13 times in 1 year	**24.00 per inch**
26 times in 1 year	**23.00 per inch**
52 times in 1 year	**22.00 per inch**

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

Replies to blind ads should be addressed as follows:
Box (give number)
Science
1515 Massachusetts Ave., NW
Washington 5, D.C.

POSITIONS OPEN

Biologist, Ph.D. To teach biology in Catholic university. Experience: bacteriology and either zoology or physiology. Rank and salary open. Box 166, SCIENCE. 7/11,18

Chemist, male, with B.S. degree in organic chemistry or biochemistry, to participate in analytical biochemical research in mental illness in hospital near Philadelphia. Write stating age, education, experience, and salary desired to P.O. Box 8507, Philadelphia 1, Pa. 7/25; 8/1, 8, 15

Experienced Cytotechnologist. Papanicolaou Research Laboratory, 1300 York Avenue, New York 21, New York. uc

POSITIONS OPEN

(a) **Bacteriologist;** Ph.D. to head nine in department of busy hospital now merging to form one very large institution; about $9000; midwestern university center. (b) **Biochemist** or **Chemist;** M.S., Ph.D. for outstanding opportunity, large cancer research hospital; to $12,500. East. (c) **Virologist;** consider **Ph.D. Microbiologist** also; research appointment, university medical school; research mainly directed human, animal virus relationships; ample technical assistance, freedom and initiative; to $8000; eastern university city. (d) **Biochemist;** M.S. for special research project in blood pigments; large mideastern hospital; college city 200,000. Woodward Medical Bureau, Ann Woodward, Director, 185 North Wabash, Chicago. X

Experienced Histology Technician, ASCP, registered preferred. Supervise histology laboratory in large midwestern teaching hospital, train technicians, opportunity for research. Box 163, SCIENCE. tf

(a) **Professor of Biology and Head of Department of Biological Sciences;** 4-year, coeducational liberal arts college, fully accredited; South. (b) **Pharmacologist,** Ph.D., to conduct research independently in fields of inflammation, analgesia, or sympatholytic drugs; 14-year old company expanding into entire field of cosmetics and allied items; laboratory staff of over 125; opening also for **Histochemist** to conduct independent research; Ph.D. required; salaries up to $10,000; Midwest. (c) **Ph.D. or V.M.D.** with training in virology, although doctorate in microbiology with some training in virology would be considered; long-term research project to study relationship between human and animal viruses; medical school research department; East. S7-3 Medical Bureau, Burneice Larson, Director, 900 North Michigan Avenue, Chicago. X

POSITIONS OPEN

Pharmacologist, Ph.D., to head small, growing department, expanding pharmaceutical manufacturer. Require ambitious, imaginative, productive scientist, under 35, seeking career opportunity in industrial pharmacology. Please send complete résumé, including publications and references. Box 170, SCIENCE. 7/25

NEW WORLD-WIDE GRADUATE AWARD DIRECTORY. First compilation ever prepared for American scientists, teachers, and librarians to subsidize their education and research in more than 350 universities in 45 states, 30 foreign lands. Stipends $200–$10,000. Complete information. Just published. Send $2 now. CRUSADE, Sci., Box 99, Station G, Brooklyn 22, N.Y. eow

SCIENCE TEACHERS, LIBRARIANS, ADMINISTRATORS urgently needed for positions in many states and foreign lands. Monthly non-fee placement journal since 1952 gives complete job data, salaries. Members' qualifications and vacancies listed free. 1 issue, $1.00. Yearly (12 issues) membership, $5.00. CRUSADE, SCI., Box 99, Station G, Brooklyn 22, N.Y. ew

POSITIONS WANTED

Biochemist, Ph.D., 1957, 28, married; year's postdoctoral terminating, teaching experience. Desires academic or industrial position. Hormonal control lipid metabolism, steroid metabolism. Broad biological background. Box 173, SCIENCE. 7/25

Botanist-Biologist, 44, Cornell Ph.D., 1951; 7 years' experience in southern state university: botany, general biology, plant taxonomy, evolution; AEC contract research, floristics, ecology, isotopes; publications; administration. Will attend AIBS. Box 172, SCIENCE. X

POSITIONS WANTED

Entomologist, Ph.D., minor in physiology; 1 year teaching in experiment station. Desires research academic position. Box 171, SCIENCE.

Pharmacologist; 8 years, professor and head, pharmacology department, state university; 4 years, director, research, pharmaceutical company. Medical Bureau, Burneice Larson, Director, 900 North Michigan Avenue, Chicago. X

The Market Place

BOOKS • SERVICES • SUPPLIES • EQUIPMENT

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26 times in 1 year	**23.00 per inch**
52 times in 1 year	**22.00 per inch**

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

BOOKS AND MAGAZINES

SCIENTIFIC JOURNALS WANTED

Sets, Runs and Volumes bought at top prices. Your wants supplied from our Back Files of over 3,000,000 periodicals. **Abrahams Magazine Service; N. Y. 3, N. Y.**

ADVANCES IN EXPERIMENTAL CARIES RESEARCH

AAAS SYMPOSIUM VOLUME

June 1955

246 pp., 6" x 9", 49 illus., index, clothbound

Price $6.75; cash order price for AAAS members **$5.75**

". . . This is a real contribution to dental science. It is the most comprehensive review of animal experimentation on caries ever attempted. The format and reproduction of illustrations are excellent.

"This compilation of research findings should have wide circulation and should be a storehouse of information for all those who are investigating the problem of dental caries. It should serve to clarify the thinking and prevent useless duplication in future studies. . . ."

Russell W. Bunting, School of Dentistry, University of Michigan.

AAAS, 1515 Mass. Ave., NW, Washington 5, D.C.

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Your sets and files of scientific journals

are needed by our library and institutional customers. Please send us lists and description of periodical files you are willing to sell at high market prices. Write Dept. A3S, CANNER'S, Inc. Boston 20, Massachusetts

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Hamsters, Guinea Pigs and Rats

J. E. STOCKER Box 4 Ramsey, N.J.

USE THIS EASY SELF-MAILER to obtain further information

18 July 1958

Readers' Service

Information Requisition

It's Simple: Mark—Clip—Fold—Mail—No stamp required

This coupon is for your convenience—to facilitate your requests for further information about advertised products and items in Equipment News.

From:

Name ..... **Position** .....

Company .....

Street .....

City ..... **Zone** .... **State** .....
(Please print or type)

Mark, clip coupon — FOLD HERE along this line — mail

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit #12711 New York, N.Y.

Readers' Service

To: SCIENCE MAGAZINE
Room 740
11 West 42 Street
New York 36, New York

Fasten Here Only
Staple, Tape, Glue

18 July 1958

Readers' Service

Information Requisition

Use this easy self-mailer to obtain further information about items or literature from the Equipment section as well as from advertised products.

EQUIPMENT

Circle below desired number corresponding to:

151 154 156 161 162 163 164 165 167 168
171 173 174 175 176 178 179 180 181

ADVERTISERS IN THIS ISSUE

In list below, check page number of advertiser from whom you would like more information. If more than one item appears in ad, letters (A, B, C) are used to indicate particular items available in order of appearance in advertisement. Where more than one ad appears on page, **"U" indicates upper ad, "L" lower ad, "I" inside ad, "M" middle ad,** and **"O" outside ad.** Advertisements in Personnel Placement and Market Place are not keyed. A multiplicity of items is indicated by *. Readers are requested to specify on this coupon the particular item in which they are interested; otherwise, the request cannot be processed.

☐ 106	☐ 107	☐ 108	☐ 109	☐ 111, A
☐ 111, B	☐ 112	☐ 114, A	☐ 114, B	☐ facing 136, A
☐ facing 136, B	☐ insert	☐ facing 137	☐ 152	☐ 153*
☐ 154, UO-A	☐ 154, UO-B	☐ 154, UO-C	☐ 154, LO	☐ 155, UI
☐ 155, UO	☐ 155, L*	☐ 156, A	☐ 156, B	☐ 157
☐ 158	☐ 159, UI	☐ 159, UO*	☐ 159, L	☐ 160*
☐ 161	☐ 164, UO	☐ 164, UI	☐ 167, UI	☐ 167, LI
☐ 167, O	☐ 168			

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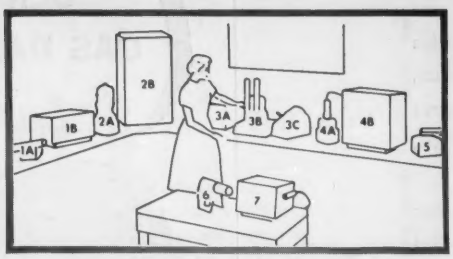
More than two years' research went into the 33 *all new* instruments that have been added to the Nuclear-Chicago line now offered to the small or large nucleonic research laboratory. Among these high-quality advance-design instruments are many completely automatic counting systems.

Whether you are just starting a modest radioisotope laboratory or expanding present facilities, call on Nuclear-Chicago. For complete details on the new Nuclear-Chicago line, write for our new Catalog "Q".

1A Model DS5-3P Scintillation Detector with exposed 2" x 2" sodium iodide crystal and **1B** Model 132 Analyzer Computer for precision gamma-ray measurements using pulse-height discrimination techniques.

2A Model DS5-5 Scintillation Well Counter with exclusive "scaler-spectrometer" circuit and **2B** Model 1820 Recording Spectrometer for automatic quantitative energy separation of gamma-ray spectra.

3A Model 183B Count-O-Matic Binary Scaler, **3B** Model C110B Automatic Sample Changer with Model D47 Gas Flow Counter, and **3C** Model C111B Printing Timer for completely automatic changing, counting, and recording of as many as 35 soft beta emitting radioactive samples.



4A Model 3054 Manual Sample Changer with Model DS5 Scintillation Detector which features interchangeable alpha, beta, or gamma sensitive crystals connected to Nuclear-Chicago's finest scaler, the **4B** Model 192A Ultrascaler. Model 192A features decade scale of 10,000, one millivolt sensitivity, and precision automatic circuitry.

5 Model 2612P Portable Survey Meter contains a 1.4 mg/cm² thin window G-M tube for surveying for alpha, beta, or gamma contamination up to 20 milliroentgens per hour.

6 Model 2586 "Cutie Pie" features interchangeable ionization chambers for measuring beta, gamma, or x-radiation up to 250 roentgens per hour.

7 Model 1620A-S Analytical Count Rate Meter offers a wide choice of full scale ranges, four time constants, wide range high voltage supply. It is shown with a Model D34 thin window G-M tube and P11 probe for continuous monitoring or analytical radioactivity determinations.

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